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Air Pollution and Acid Rain
Report No. 15

# A Regional Survey of Chemistry of Headwater Lakes and Streams in New England: Vulnerability to Acidification

Office of Research and Development
U.S. Environmental Protection Agency

Fish and Wildlife Service
**U.S. Department of the Interior**

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

EASTERN ENERGY AND LAND USE TEAM
Route 3, Box 44
Kearneysville, West Virginia 25430

Dear Colleague:

The Eastern Energy and Land Use Team (EELUT) is pleased to provide you this report on the results of a regional survey of the chemistry of headwater lakes and streams in the New England states. This study was conducted to assess the status of these waters with respect to acidification. The report is a part of the EELUT series on air pollution and acid rain. Other reports in this series are listed on the inside front cover.

The extent and location of surface waters that are acidified or vulnerable to acidification was determined from a survey of 226 headwater lakes and low order streams in six New England states. This data was compared to historical temporal trends, and were used to evaluate proposed models of acidification and to identify potential indicators of acidification. A companion study (FWS/OBS-80/40.17) provides similar information for the middle Atlantic states.

Please feel free to send suggestions or comments to EELUT so that we may continually strive to improve our future products.

Sincerely,

R. Kent Schreiber

R. Kent Schreiber
Acting Team Leader, EELUT

B

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FWS/OBS-80/40.15
April 1983

Air Pollution and Acid Rain
Report No. 15

# A REGIONAL SURVEY OF THE CHEMISTRY OF HEADWATER LAKES AND STREAMS IN NEW ENGLAND: VULNERABILITY TO ACIDIFICATION

by

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Fish and Wildlife Service

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## DISCLAIMER

Although the research described in this report has been funded wholly or in part by the U.S. Environmental Protection Agency through Interagency Agreement No. EPA-82-D-X0581 to the U.S. Fish and Wildlife Service, it has not been subjected to the Agency's required peer and policy review and therefore does not necessarily reflect the views of the Agency.

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# EXECUTIVE SUMMARY

A survey was conducted of 226 headwater lakes and low order streams in the six New England states. The waters selected were relatively undisturbed by direct human disturbance and were low in color. The sites were stratified by geographic area, and by bedrock geology and soil cation exchange capacity.

Acidic (pH $<5$) surface waters occurred in every state. Approximately 8% of the waters surveyed were pH $<5$, and 29% were pH $<6$. The low pH waters tended to occur in clusters, although high pH waters frequently occurred in the same area. Waters with low alkalinity content were more common than low pH waters, and tended to occur in the same areas as the acidic waters. Approximately 24% of the waters had alkalinity concentrations of 20 $\mu eq\ l^{-1}$ or less, 41% had concentrations of 100 $\mu eq\ l^{-1}$ or less, and 53% were 200 $\mu eq\ l^{-1}$ or less. The proportion of acidic surface waters in New England is similar to that in other areas where bedrock is low in buffering capacity and precipitation is similarly acidic. Hydrogen ion content was not correlated with color, an index of organic acids. Therefore the acidic lakes are not primarily the result of natural organic acids. Highly colored, acidic lakes were excluded from the survey.

Calcite saturation index (CSI) results were similar to alkalinity, and CSI and alkalinity were highly correlated. Approximately 59% of the waters surveyed had CSI values greater than 3, and were classed as susceptible to acidification. This is the same conclusion reached based on alkalinity data. Specific conductance, an index of total ionic concentration, was correlated with alkalinity and could be used as a simple index of vulnerability to acidification. However, the coefficient of correlation was low.

The lakes and streams surveyed contained appreciable sulfate concentrations (80-120 $\mu eq\ l^{-1}$) that could not be attributed to marine aerosols. The concentrations were similar to those found in other areas where precipitation is similarly acidic but were relatively uniform, and sulfate was not positively correlated with hydrogen ion as observed in other surveys. The lack of correlation may result because precipitation, and thus sulfate deposition, is chemically uniform over the region surveyed.

Aluminum and manganese concentrations of the lakes and streams surveyed were correlated with hydrogen ion content, although the correlation was weak for manganese. The regression for aluminum was very similar to that obtained from other regional surveys and apparently represents the thermodynamic equilibrium between hydrogen ion and aluminum. Of the 226 waters surveyed, 13 had aluminum concentrations of 200 $\mu g\ l^{-1}$ or more and pH of 5.5 or lower, conditions that may be toxic to sensitive fish species.

Of the physical factors measured, the ones most highly related to buffering capacity and acidity were bedrock geology and, to a lesser extent, soil cation exchange capacity. A sensitive lake or stream, as determined by alkalinity, was nine times more likely to be found in an area where bedrock was low in buffering capacity. A sensitive lake or stream was three times more likely to be found in an area where soils were low in cation exchange capacity. Soil class was correlated with bedrock class, with sensitive soil classes largely found in areas where bedrock was also sensitive. In headwater areas soils tend to be thin and therefore may be less important than bedrock in these areas in determining water chemistry.

The only other physical factors of importance were lake area and stream order. Lakes of all sizes were low in alkalinity but only lakes of 20 ha area or smaller were acidic. Higher order streams were higher in pH and alkalinity. This suggests that some factor related to watershed size may be an important factor in neutralizing acid deposition, and watershed size was correlated with lake pH for lakes in Maine. The waters surveyed were selected to be low in human disturbance. Disturbance was also correlated with bedrock geology, probably as a result of topography, confounding the effects of disturbance on water chemistry.

Historical pH and alkalinity data indicate that waters located in areas where buffering capacity is low have been acidified. Of the 95 lakes with usable historical pH data, 61 (64%) were lower in pH in this survey. Of 56 lakes for which historical alkalinity data were located, 39 (70%) were lower in the present survey. The average lake for which historical data were available increased in hydrogen ion content five-fold and decreased in alkalinity by 60%.

The relationship between pH and calcium content of surface waters (Henriksen model) was tested as an indicator of acidification. This model predicted that 57% of the waters surveyed had been acidified, a value in good agreement with that obtained from lakes for which historical water chemistry data were found. The model further predicted an average loss of about 50 $\mu eq\ l^{-1}$ of alkalinity. Historical data, all from low alkalinity lakes, indicated a decline of about 100 $\mu eq\ l^{-1}$. Given the large range of chemical conditions encountered, this was considered to be reasonably good agreement. The Kramer model gave good agreement with the data, 75% of the samples were within 0.5 pH unit of the predicted pH based on carbonic acid weathering alone. The remaining 25% of the samples were more than 0.5 pH unit lower than predicted and are presumed to be acidified. The Thompson model also gave good agreement with the data and a similar prediction of acidification. The Kramer and Thompson models yield similar predictions of acidification that are about half that of the Henriksen model.

We conclude that a substantial portion of the headwater lakes and low order streams in New England are vulnerable to acidification, and that alkalinity is the best measure of vulnerability. Bedrock geology was the best physical factor that could be used to predict surface water alkalinity, and thus vulnerability to acidification, but a substantial portion of the waters that were predicted to be vulnerable were not. Both historical water chemistry comparisons and acidification models indicate that the vulnerable lakes have declined in alkalinity and increased in hydrogen ion content, presumably as the result of atmospheric deposition of acid.

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# INTRODUCTION

The precipitation that falls on the northeastern United States is highly acidic compared to that in much of western North America. The annual weighted mean pH of this precipitation ranges from 4.2 to 4.4 (National Atmospheric Deposition Program 1981). Acidic precipitation has been identified as the cause of acidification of surface waters, and consequently adverse effects on aquatic organisms, in Scandinavia (Almer et al. 1978; Muniz and Leivestad 1980), Ontario, Canada (Harvey 1980), and New York (Pfeiffer and Festa 1980).

The effects of acidic precipitation on aquatic ecosystems depends on a variety of climatic, geologic, topographic, morphometric, biotic, and anthropogenic factors (Galloway and Cowling 1978). The relative importance of these factors is presently poorly understood, and the identification and quantification of aquatic resources at risk from acidic precipitation has been inadequate. In the United States the effects of acidic precipitation on surface water chemistry and aquatic biota has been documented only for the Adirondack mountain region of New York. Several studies have predicted that substantial portions of the northeastern United States are vulnerable to acidification based on indirect evidence (Galloway and Cowling 1978; Hendrey et al. 1980), but these predictions have not been widely tested.

A number of models of acidification have been proposed (Henriksen 1980; Thompson 1982). These models predict vulnerability of surface waters to acidification based on chemical interrelationships, and estimate the amount of acidification that has already occurred. These models have not been tested in the northeastern United States. Existing water chemistry data bases are not satisfactory for this purpose as most sites are located in productive lowland areas, consist of large lakes or high order streams, and have been affected by direct anthropogenic activitity (e.g., agriculture, waste disposal).

This study was conducted to collect appropriate water chemistry data to assess the chemical status of headwater lakes and streams in the northeastern United States with respect to acidification. From these data the extent and location of surface waters that are acidified or vulnerable to acidification was determined. The data were compared to historical temporal trends, and were used to evaluate proposed models of acidification and to identify potential indicators of acidification.

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# METHODS

## Selection of Sampling Sites

Surface waters suitable for use in this study were selected from all available waters according to the following:

- geographic coverage
- bedrock buffering capacity
- soil cation exchange capacity
- location in watershed
- direct human disturbance in watershed
- availability of historical data
- access

The waters sampled were primarily lakes (193 of 226; 85%). Streams were sampled only when a suitable lake could not be located in a desired area, or was not accessible either physically or legally.

Geographic distribution of lakes over the region was as uniform as possible. A few areas were inadequately represented. For example, it was very difficult to locate undisturbed lakes with public access in Connecticut.

Sampling sites were selected to represent all classes of bedrock buffering capacity and soil cation exchange capacity present in the region. Bedrock buffering capacity classes were those described in Hendrey et al. (1980), and soil cation exchange capacity groups were those of McFee (1980). The original maps depicting the distribution of these factors were obtained from the authors (S. Norton, Dept. of Geology, University of Maine, Orono, Maine 04469; W. McFee, Dept. of Agronomy, Purdue University, West Lafayette, Indiana 47907). These maps were generally of 1:500,000 scale, the same as the U.S. Geological Survey state base map. Lakes were selected to represent the various categories in rough proportion to the area of the categories in each state. Lakes may have been misclassified because of errors in precisely locating the lake on the state base map (many small lakes are not shown on these maps and locations were transferred from 7½ or 15 minute quadrangle maps), or because of loss of resolution on the geology and soil maps as a result of scale or smoothing.

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Headwater sites were generally low in direct human disturbance of watershed. Many otherwise suitable lakes were rejected because of disturbance in the watershed. In some cases, if no alternate lakes or streams better fit the criteria, disturbed waters were sampled. An arbitrary code was devised that represented differing levels of disturbance encountered, and waters were assigned a code based on a visual survey of the lake shoreline and visible portions of the watershed (Table 1).

In each state contact was made with the appropriate state agency responsible for water chemistry data records (e.g., fish and game department, water quality department), and any federal entity managing aquatic resources in the state (e.g., U.S. Forest Service). Agencies were asked to supply existing historical water chemistry data as well as to suggest potential sampling locations. Particular attention was given to selecting sampling sites for which there were historical data available; about half (95 of 226) of the final sites had such data.

Finally, accessibility of the sites was considered in making a final selection. Preferred sites were at least one half mile from the nearest vehicle access point, but not more than two miles from that point. Most sites had a marked foottrail leading from the access point to the lake.

Although size was not a selection criterion lakes fitting the above criteria were generally small. Lakes larger than 75 ha were not sampled. Data on watershed area were available for lakes located in the state of Maine (M. Hutchins, Environmental Studies Center, University of Maine, Orono, Maine). Watershed area was included as a variable in this subset of the data.

## Sample Collection Procedure

Each water body selected for survey was visited by a two person survey team. Most waters were reached on foot, but a few were reached by fixed-wing aircraft or pontoon-equipped helicopter. A standardized sampling procedure was followed:

- Survey watershed: one person walked as much of the shoreline as feasible, taking note of the major vegetation, exposed bedrock, inflow and outflow streams, aquatic vegetation, and evidence of human activity (roads, campsites, seasonal dwellings, permanent dwellings, logging, agriculture). Such observations were made on the trip into and out of the area as well.
- Collect water samples: one person waded to the center of a stream or rowed to the deepest area of a lake in an inflatable raft. In streams, water samples were collected from mid-depth directly into the sample bottles. In lakes, one set of samples was collected at 0.1 m below the surface directly into the sample bottles and one set near the

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Table 1. Criteria Used to Estimate Relative Amount of Human Disturbance

| Code | Disturbance |
|---|---|
| 1 | No visible disturbance: access by foot trail or aircraft only. |
| 2 | Slight disturbance: access by 4-wheel drive vehicle: one or two seasonal dwellings in the watershed; evidence of logging activity but not presently active. |
| 3 | Moderate disturbance: access by 2-wheel drive vehicle; more than two seasonal dwellings; evidence of active logging but not immediately adjacent to water. |
| 4 | Severe disturbance: access by paved road; permanent homes around lake; agriculture in watershed; active logging adjacent to water. |

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> bottom (without disturbing sediment) in a plastic Van Dorn-type water sampler. Water temperature was measured with a pocket thermometer at the time of collection. Water samples were placed in acid-washed, distilled water rinsed linear polyethylene bottles. Each set of samples consisted of three bottles -- one 500 ml for pH, alkalinity, specific conductance, and color; one 250 ml for sulfate and chloride; and one 125 ml for cations. The 125 ml bottle contained 6.25 ml of 4N nitric acid. Each bottle (except the cation sample bottle) was rinsed with sample water twice before filling. Samples were placed on ice within 1 hour after collection.

The samples were generally collected during the open water period, but a few were collected through the ice. Previous experience indicated that, except for the spring run-off period, water chemistry in these waters is relatively stable throughout the year. In any event, geographic variability far exceeds temporal variation in individual waters. The lakes sampled were not euthropic or dystrophic. Inasmuch as the surface and deep samples were chemically similar, there was no evidence that algal production or hypolimnion decomposition significantly affected water chemistry in these lakes.

## ANALYTICAL METHODS

### Field Procedures

Analyses of pH, alkalinity, specific conductance, and color were performed at field locations. Within 8 hours after sampling, and as soon as possible, the 500 ml bottle was removed from ice and warmed to room temperature. Two 100 ml aliquots were removed for determination of pH and alkalinity. The pH was measured with a portable meter (Fisher model 107 or Cole Parmer DigiSense) equipped with a plastic-body, gel filled combination electrode. The meter was standardized with pH 7 and 4 buffers, and electrode response was verified by measuring the pH of dilute sulfuric acid solutions of theoretical pH 4. If measured values deviated from expected values by more than 0.1 pH units the electrode was discarded. The electrode was rinsed thoroughly with distilled water, blotted dry, and soaked in the sample for 15 minutes or longer -- until three successive readings at 1 minute intervals were identical -- and pH was recorded.

Alkalinity was determined by titrating each of the 100 ml sample aliquots with 0.0200 N sulfuric acid to pH $\sim$4. Acid was added in 0.10 ml portions using a micro syringe until pH 5 was reached, then in 0.05 ml portions to pH <4. The pH was recorded after equilibration following each addition of acid. Alkalinity was calculated by two methods. Inflection point alkalinity was determined by the method of Gran (Stumm and Morgan 1970), and fixed endpoint (pH 4.5) alkalinity was determined as described in American Public Health Association et al. (1975). Inflection point results were used for all analyses and

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comparisons except for those using historical data, where fixed endpoint data were used.

Two 50 ml aliquots of sample were measured and used for determination of specific conductance and color. Specific conductance was measured with a calibrated meter (Markson Scientific Company model 10), and apparent color was determined by comparison of unfiltered samples with platinum cobalt standard solution (LaMotte Chemical Company, Chestertown, Maryland).

### Laboratory Procedures

The remaining water samples were kept on ice, returned to the laboratory, and kept refrigerated until analyzed. The unacidified 250 ml water sample was used for measurement of sulfate by the microthorin method (Fritz and Yamamura 1955), and chloride by the ferricyanide method (American Public Health Association et al. 1975). All analyses were performed in replicate. The acidified 125 ml sample was used for measurement of cations. Sodium and potassium were measured with air-acetylene flame atomic absorption spectrophotometry (AAS; Perkin Elmer model 703), calcium and magnesium by nitrous oxide-acetylene flame AAS, and manganese by graphite furnace AAS. Aluminum was measured initially by the colorimetric method of Dougan and Wilson (1974), and later by graphite furnace AAS. The two methods gave comparable results. As samples were unfiltered, the results obtained represent total concentrations of the various ions.

Calcite saturation index (CSI) was calculated from the equation given by Kramer (1976). For samples where alkalinity was zero or negative, a modified equation (Kramer 1981) that approximates CSI was used.

A subset of 31 samples ranging in color from 0 to 260 units were analyzed for total organic carbon (TOC) by G. Glass, U.S. Environmental Protection Agency, Duluth, MN. A linear regression analysis was performed to determine the relationship between color and TOC.

### Quality Assurance

The functioning of analytical instruments was assured by frequent analysis of known standards. Response of pH, specific conductance, spectrophotometers and atomic absorption spectrophotometers was checked daily. Most analyses were performed in replicate to enable calculation of variance. U.S. Environmental Protection Agency Water Pollution Control Samples for Trace Metals, and Minerals (EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio), were analyzed following the same procedures used for water samples. An interlaboratory exchange of samples was conducted with the Norwegian Institute for Water Research.

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As a further check on analytical accuracy and data coding errors, we calculated total ionic balance and theoretical specific conductance. All ion concentrations were converted to units of $\mu$eq $l^{-1}$, anions and cations were summed, and the sum of anions was compared to the sum of cations for each sample. Theoretical specific conductance was calculated by multiplying ion concentrations by equivalent conductance values for 25°C obtained from the Handbook of Chemistry and Physics (Weast 1978). Theoretical conductance was compared to measured conductance for each sample.

### Data Analysis

Results obtained from the above analyses were entered into a SAS (Statistical Analysis System, Raleigh, NC) data set operating on an IBM model 4341 computer located at the University of Maine, Orono, Maine. SAS statistical analysis and graphic routines were used for data analysis. Punch cards produced from this data set were sent to Paul Rago, U.S. Fish and Wildlife Service, Ann Arbor, MI, where they were entered into a MIDAS (Michigan Interactive Data Analysis System) data set using the University of Michigan computer system. This system was employed for analysis of variance and multivariate data analysis.

### Historical Data

Historical pH and alkalinity data were obtained through correspondence with water chemistry and fisheries offices in the six states. All such data were for lakes. Data were screened for obvious errors and only data for which the method of collection was documented and reasonable were incorporated in this study.

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## RESULTS AND DISCUSSION

### Quality Assurance

The laboratory analyses of EPA Quality Assurance Samples for Minerals (Table 2) and Trace Metals (Table 3) gave acceptable accuracy. The coefficient of variation was always less than 5% for minerals and less than 10% for trace elements. The element determined with poorest precision was aluminum; however, the recoveries we obtained were comparable to those reported by EPA, and our standard deviations were smaller. An interlaboratory comparison was conducted with the Norwegian Institute for Water Research for calcium, magnesium, sodium, and potassium determinations on 21 water samples collected in Norway, and sulfate and chloride determinations on 18 water samples collected in Maine. The following linear regression equations were obtained:

Calcium (ME) = 1.02 Calcium (NIVA) -0.03
Magnesium (ME) = 0.97 Magnesium (NIVA) + 0.003
Sodium (ME) = 1.06 Sodium (NIVA) + 0.01
Potassium (ME) = 0.97 Potassium (NIVA) = 0.03
Sulfate (ME) = 0.94 Sulfate (NIVA) + 0.33
Chloride (ME) = 1.09 Chloride (NIVA) -0.19

In all cases intercepts were not different from zero and slopes were not different from one (t test, $p < 0.05$).

Recovery of known additions of trace metals and minerals was always within 5% of that expected. The pH of dilute sulfuric acid solutions was always within 0.1 units of theoretical. In those instances where results deviated from theoretical by more than this amount, the electrode was replaced and the meter recalibrated. Acceptable results were then obtained.

A further check on the accuracy of water chemistry determinations was made by comparison of the sum of anions and the sum of cations (Figure 1), and of theoretical and measured conductance (Figure 2). The sums of ions were nearly equal, with only two obvious outliers. The line of best fit had an intercept of 14 $\mu eq\ l^{-1}$ and a slope of 1.00, not significantly different from 0 and 1.0 respectively ($p < 0.0001$). The linear correlation was highly significant ($r^2 = 0.97$, $p < 0.0001$). The line of best fit for theoretical and measured conductances had an intercept of -1.22 $\mu S\ cm^{-1}$, and a slope of 1.12, both not

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Table 2. Results of Analysis of EPA Water Pollution Quality Control Samples for Minerals. Mean Values for PH were Computed from Hydrogen Ion Concentrations

| EPA sample number | Factor | True value | Laboratory results | | | |
|---|---|---|---|---|---|---|
| | | | $\bar{X}$ (N=3) | S.D. | C.V. | 95% C.I. |
| 3 | pH (units) | 7.4 | 7.53 | - | 2.3 | 7.51-7.57 |
| | Calcium (mg/1) | 6.7 | 6.8 | 0.2 | 2.9 | 6.5-7.1 |
| | Magnesium (mg/1) | 2.4 | 2.4 | 0.05 | 2.1 | 2.3-2.5 |
| | Potassium (mg/1) | 1.7 | 1.6 | 0.06 | 3.8 | 1.5-1.7 |
| | Sodium (mg/1) | 7.0 | 7.2 | 0.06 | 0.8 | 7.1-7.3 |
| 4 | pH (units) | 8.6 | 8.56 | - | 4.6 | 8.51-8.62 |
| | Calcium (mg/1) | 32.0 | 34.8 | 0.2 | 0.6 | 34.3-35.3 |
| | Magnesium (mg/1) | 7.1 | 7.1 | 0.1 | 1.4 | 6.9-7.3 |
| | Potassium (mg/1) | 7.2 | 7.5 | 0.06 | 0.8 | 7.4-7.6 |
| | Sodium (mg/1) | 40.0 | 40.1 | 0.1 | 0.3 | 39.9-40.3 |

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Table 3. Results of Analysis of EPA Water Quality Control Samples for Trace Metals

| EPA sample number | Element | True Value | Laboratory results |  |  |  | EPA Recovery |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | $\bar{X}$ (N=3) | S.D. | C.V. | 95% C.I. | $\bar{X}$ | S.D. | C.V. | 95% C.I. |
| 1 | Al | 350 | 474.3 | 29.9 | 7.1 | 350.1-498.5 | 369 | 41.7 | 11.3 | 286-452 |
|  | Mn | 55 | 62.3 | 2.6 | 4.2 | 58.2-66.4 | 54.8 | 5.7 | 10.4 | 43.4-66.2 |
| 2 | Al | 50 | 68.3 | 5.5 | 8.1 | 54.5-82.0 | 74.9 | 24.3 | 32.4 | 26.1-123 |
|  | Mn | 11 | 13.7 | 0.6 | 4.4 | 12.2-15.2 | 11.0 | 3.8 | 34.5 | 3.2-18.6 |
| 3 | Al | 700 | 726.7 | 46.2 | 6.4 | 612.0-841.4 | 712 | 62.1 | 8.7 | 588-836 |
|  | Mn | 350 | 387.5 | 6.5 | 1.7 | 377.2-398.8 | 348 | 18.6 | 5.3 | 311-385 |

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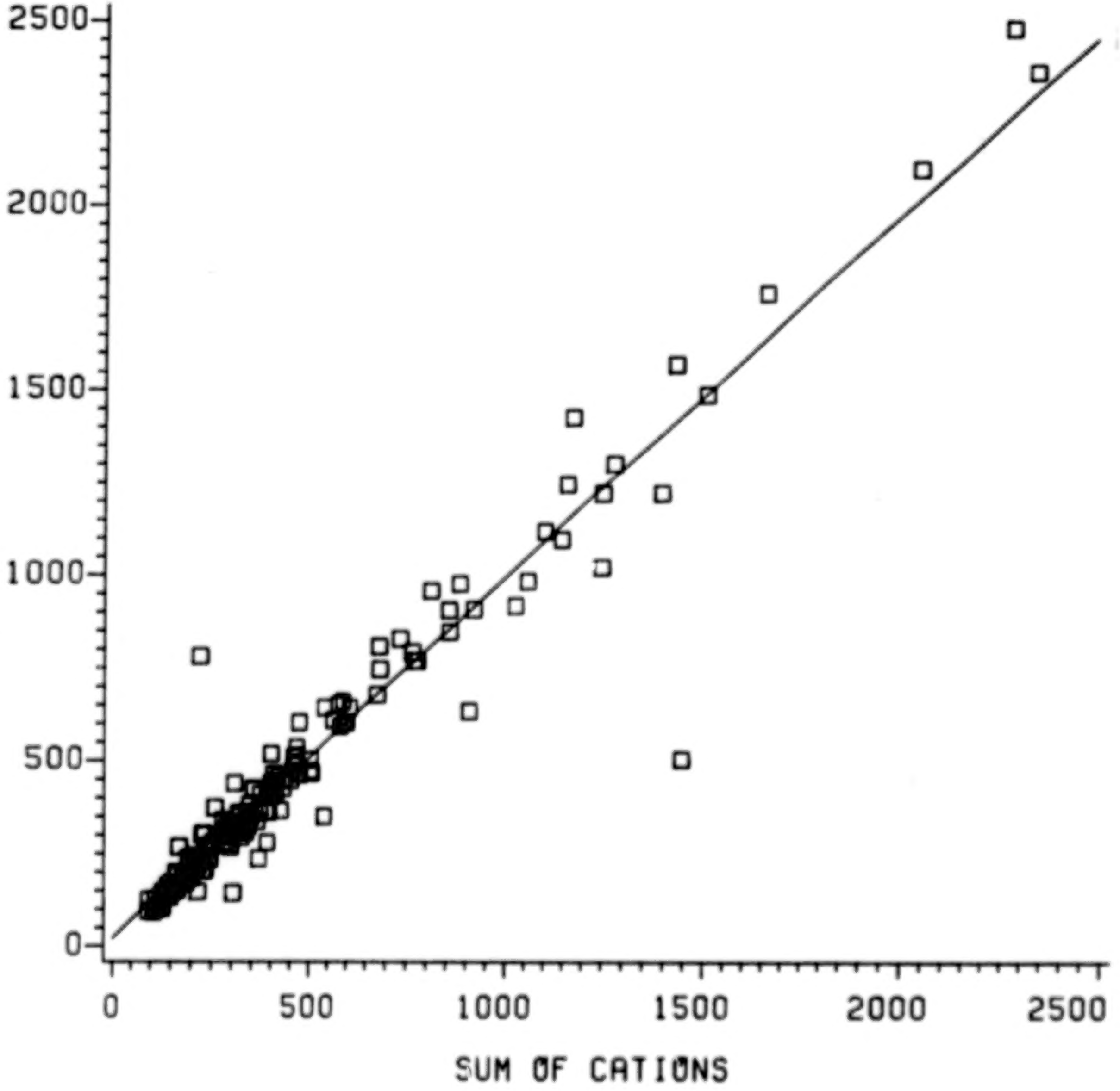

Figure 1. Sum of total anions versus sum of total cations in µeq l$^{-1}$ for 195 sites, surface samples only. Least squares regression equation: Anions = 14 + 1.00 Cations ($\underline{r}^2$ = 0.97).

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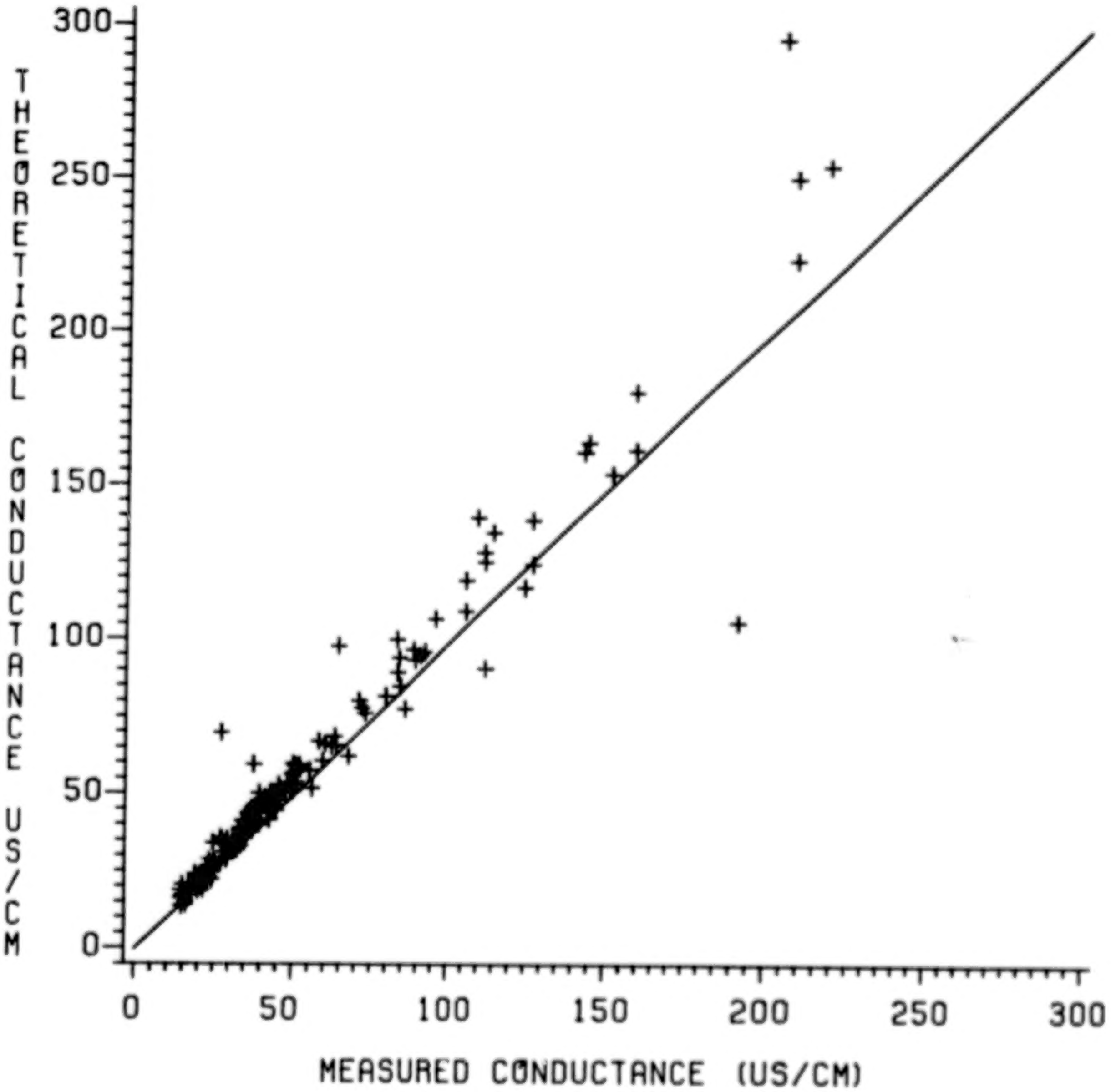

Figure 2. Theoretical versus measured specific conductance for 195 sites, surface samples only. Least squares regression equation: Theor. Cond. = -1.22 + 1.12 Meas. Cond. ($r^2$ = 0.97).

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significantly different from 0 and 1.0, respectively ($p < 0.0001$). The linear regression was highly significant ($r^2 = 0.97$; $p = < 0.0001$). These two comparisons indicate that there are no major analytical or coding errors in the water chemistry data set.

## Site Distribution

We sampled 226 lakes and streams in the six New England states (Figure 3). Many other sites were visited and rejected as unsuitable for inclusion in this study, because of high color, disturbance in the watershed, and other reasons. The distribution of sites among states (Table 4) was roughly proportional to the state area. Lakes comprised 85% of the sites and streams 15% (Table 4). Streams were sampled only when a suitable lake could not be located in the desired area. The lakes sampled were either seepage lakes with no visible inlet (N=122) or drainage lakes with permanent inlets and outlets (N=71). Stream order ranged from 1 to 4 (N: 1=15, 2=5, 3=2, 4=11).

The sample sites were distributed among bedrock geology classes in proportion to the area of each state that was underlain by each bedrock class (Table 5). Sites were selected in areas within each soil class present in each state (Table 5), but the proportional distribution was not determined. Most bedrock types were represented in rough proportion to the proportion of land area in each state, especially classes 1 and 2. All soil classes present were represented, but the proportional distribution by land area is not known.

## CHEMICAL FACTORS

### pH and Alkalinity

Surface waters of pH <5 were found in all six states (Figure 4). Nineteen sites (8%) were in this category. Sixty-five sites (29%) had pH <6. The low pH waters tend to occur in clusters, i.e. southeastern Maine, northern and southern Vermont, etc. A similar distribution was found for low alkalinity waters (Figure 5). There were 53 sites (24%) with alkalinity $\leq 20\ \mu eq\ l^{-1}$, 93 (41%) with alkalinity $\leq 100\ \mu eq\ l^{-1}$, and 120 (53%) with alkalinity $\leq 200\ \mu eq\ l^{-1}$.

A number of other regional surveys of surface water chemistry have been conducted. Results from the distribution of lakes by pH range for areas where precipitation is acidic (pH<4.6 weighted annual average) and non-acidic (pH>4.6) are summarized in Table 6. There is a pronounced difference in the proportion of acidic lakes (pH<5) between areas that do and do not receive acidic precipitation. Within the acidic precipitation group, however, there is considerable variation in the proportion of lakes in each pH range. This is not surprising considering the number of factors that may affect lake pH (e.g., organic acids, bedrock geology, soil chemistry, wastershed size, land use, etc.), and the variability in the procedures followed in the different

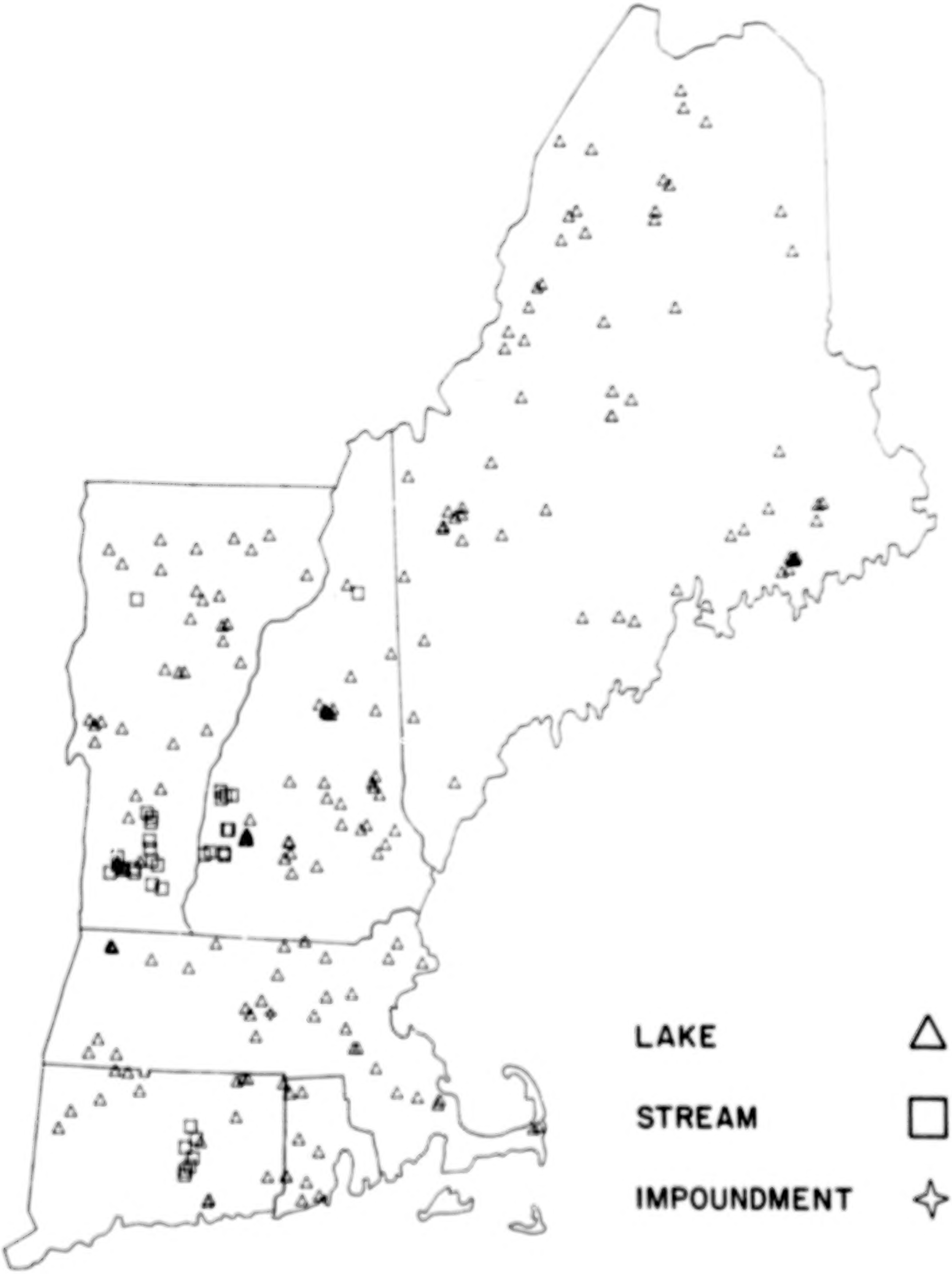

Figure 3. Map of New England showing the location of the 226 sample sites and type of water body sampled.

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Table 4. Number of Lakes and Streams Sampled in Each State

| State | Number of lakes | Number of streams |
|---|---|---|
| Connecticut | 16 | 7 |
| Maine | 62 | 0 |
| Massachusetts | 34 | 0 |
| New Hampshire | 38 | 11 |
| Rhode Island | 8 | 0 |
| Vermont | 35 | 15 |
| Total Number | 193 | 33 |
| Grand Total | 226 | |

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Table 5. Distribution of Sample Sites Among Bedrock Geology and Soil Class. Bedrock Geology Classes are those Described by Hendrey *et al.* (1980), and Soil Classes are those of McFee (1980). A Dash Indicates that that Category was not Present

|  | Number of sites | Percent of state area in bedrock class |  |  |  | Number (and %) of sample sites in bedrock class |  |  |  | Number (and %) of sample sites in soil class |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | $SS_1$ | $SS_2$ | NS |
| Connecticut | 23 | 8 | 85 | 5 | 2 | 1<br>(4) | 21<br>(92) | 1<br>(4) | 0 | 13<br>(57) | 4<br>(17) | 6<br>(26) |
| Maine | 62 | 17 | 55 | 20 | 8 | 18<br>(29) | 38<br>(61) | 6<br>(10) | 0 | 7<br>(11) | 33<br>(53) | 22<br>(36) |
| Massachusetts | 34 | 32 | 31 | 27 | 10 | 18<br>(56) | 6<br>(19) | 6<br>(2) | 2<br>(6) | 7<br>(21) | 18<br>(53) | 9<br>(26) |
| New Hampshire | 49 | 30 | 68 | 1 | 1 | 11<br>(22) | 38<br>(78) | 0 | 0 | 17<br>(35) |  | 34<br>(65) |
| Rhode Island | 8 | 63 | 35 | 2 | 0 | 7<br>(88) | 1<br>(12) | 0 | - | 3<br>(38) | 2<br>(24) | 3<br>(38) |
| Vermont | 50 | 3 | 51 | 30 | 16 | 5<br>(10) | 33<br>(66) | 8<br>(16) | 4<br>(8) | 2<br>(4) |  | 48<br>(96) |

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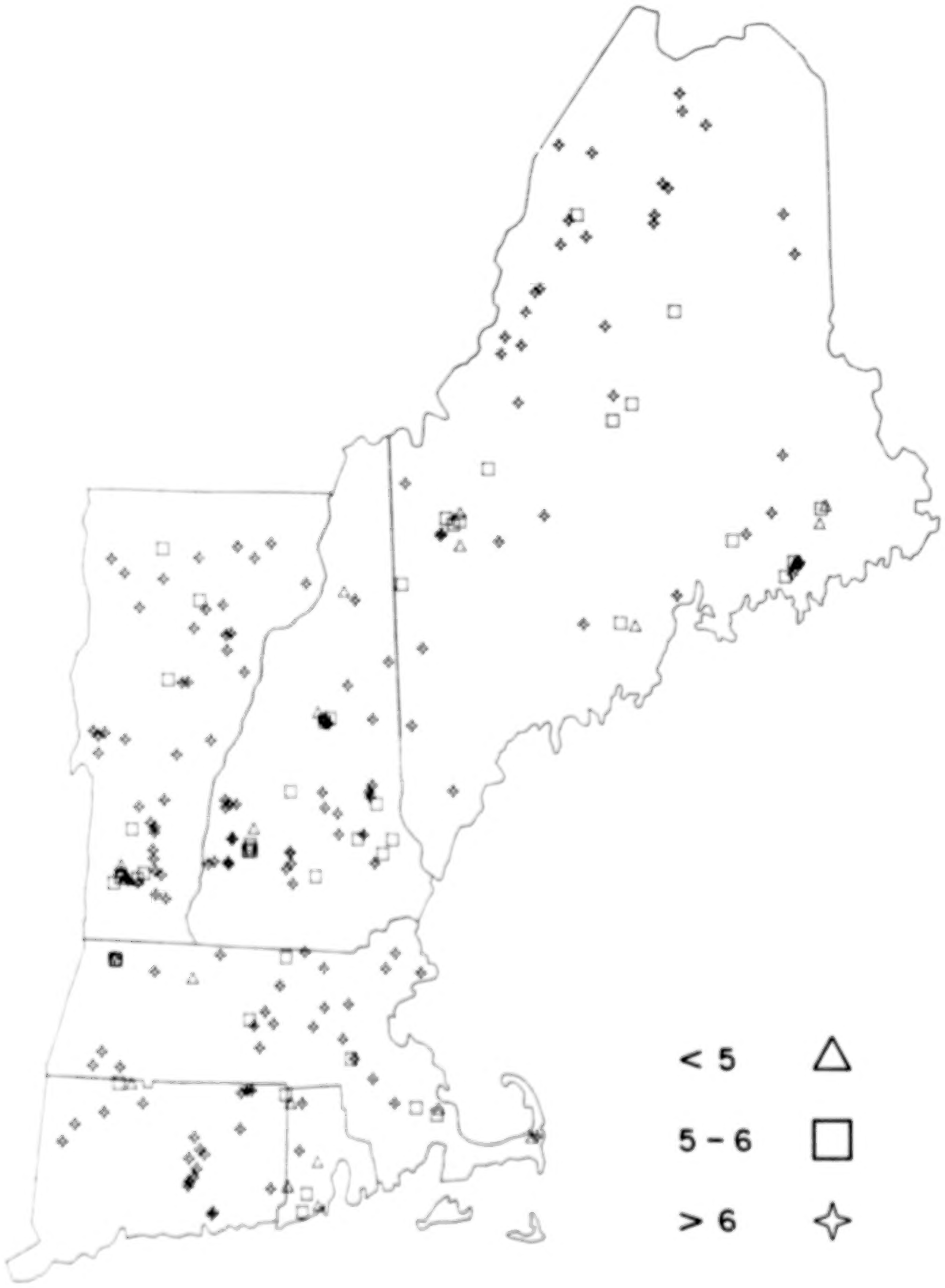

Figure 4. Map of New England showing the distribution of surface water samples by pH. Data are for surface samples only and are means of two replicates.

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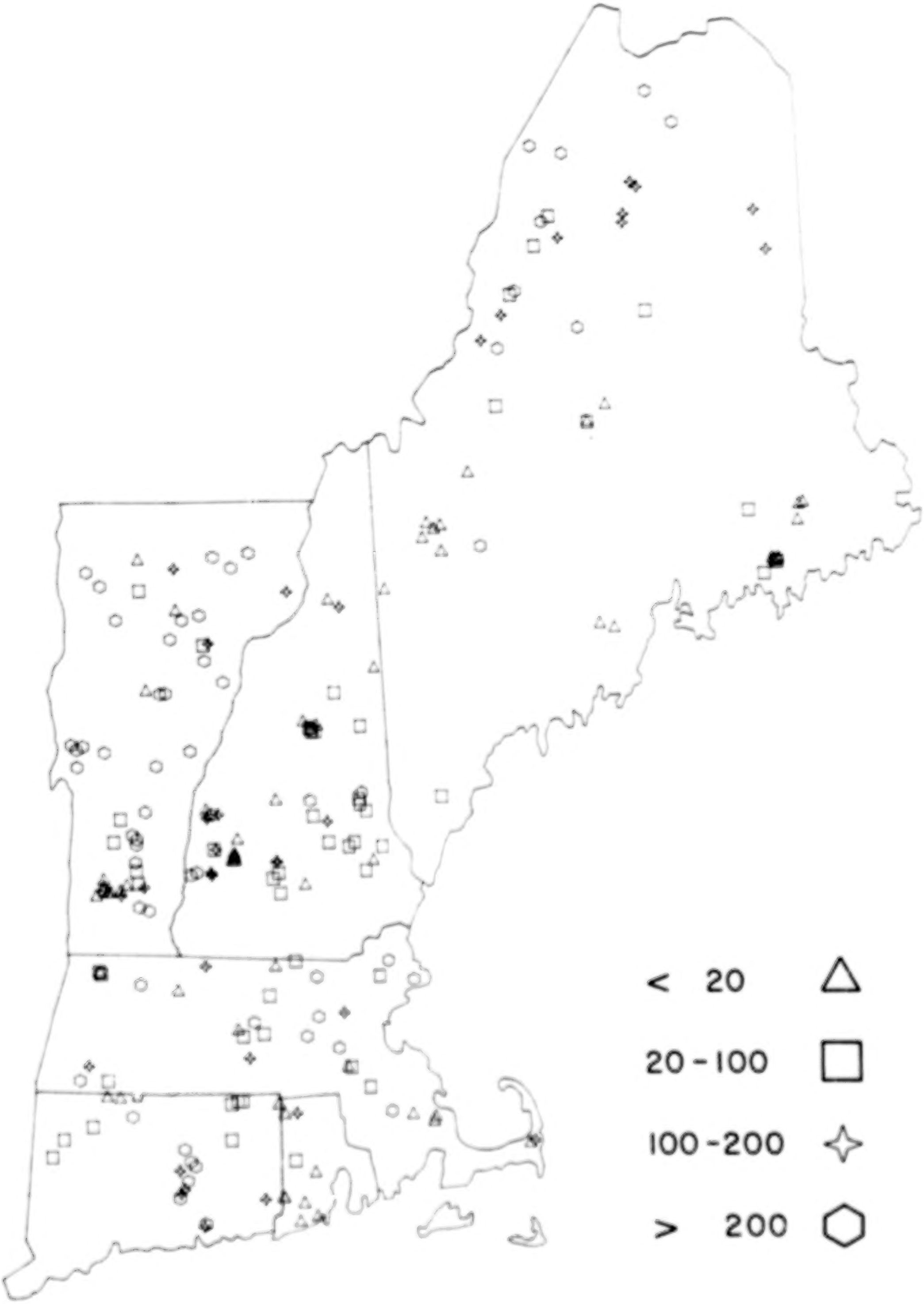

Figure 5. Map of New England showing the distribution of sample sites by alkalinity. Data are for surface samples only and are means of two replicates.

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Table 6. Regional Water Chemistry Survey Results for Surface Water PH Distribution

| Location | Number | Percent in pH range | | | Reference |
|---|---|---|---|---|---|
| | | <5 | 5-6 | >6 | |
| | | Areas Where Precipitation Averages <pH 4.6 | | | |
| New England | 226 | 8 | 21 | 71 | This Study |
| West Sweden | 314 | 36 | 21 | 43 | Almer et al. 1974 |
| West Sweden | 15 | 27 | 47 | 27 | Dickson 1975 |
| South Sweden | 51 | 2 | 20 | 78 | Malmer 1975 |
| South Norway | 155 | 18 | 38 | 44 | Wright et al. 1977 |
| South Norway | 719 | 64 | 33 | 3 | Wright and Snekvik 1978 |
| Denmark | 14 | 29 | 57 | 14 | Rebsdorf 1980 |
| Scotland | 72 | 26 | 36 | 38 | Wright et at. 1980 |
| Nova Scotia | 21 | 52 | 24 | 24 | Watt et al. 1979 |
| Quebec | 25 | 12 | 40 | 48 | Jones et al. 1980 |
| Central Ontario | 26 | 8 | 58 | 34 | Scheider et al. 1979 |
| La Cloche Mountains | 152 | 28 | 34 | 38 | Beamish and Harvey 1972 |
| Sudbury | 150 | 13 | 15 | 72 | Conroy et al. 1976 |
| Adirondack Mountains | 849 | 25 | 30 | 45 | Pfeiffer and Festa 1980 |
| | | Areas Where Precipitation Averages >pH 4.6 | | | |
| North Norway | 77 | 0 | 13 | 87 | Wright and Gjessing 1976 |
| Northwest Wisconsin | 265 | 0 | 6 | 94 | Lillie and Mason 1980 |
| North Minnesota | 85 | 0 | 0 | 100 | Glass and Loucks 1980 |

surveys. For example, Wright et al. (1977) followed a randomization procedure to select an unbiased set of lakes in south Norway, whereas Wright and Snekvik (1978) working in the same area surveyed only lakes for which fish population data were available, although they avoided very large or highly disturbed lakes. New England falls within the low end of the range of the proportion of acidic lakes, being similar to south Sweden and central Ontario. Although we selected small, headwater, undisturbed waters for our survey, we attempted to obtain a representative sample from a large (168,000 km$^2$) area with wide chemical diversity. Many other surveys were restricted to areas where buffering capacity was known to be low.

Regional surveys that included alkalinity measurements are less common (Table 7). Again, there is a pronounced difference between regions where precipitation is acidic and regions where it is non-acidic with respect to the proportion of low alkalinity waters found. Waters with total alkalinity $\leq 20$ µeq l$^{-1}$ or $\leq 100$ µeq l$^{-1}$ are much more common in areas that receive acidic precipitation. New England is intermediate in alkalinity in the group of regions that receive acidic precipitation. As the regions are all known to be low in buffering capacity, the increased proportion of very low alkalinity waters in acid rain districts may be the result of titration of alkalinity by deposition of excess hydrogen ion.

## Calcite Saturation Index

CSI has been proposed as an index of vulnerability to acidification that is superior to a simple measure of buffering capacity (Kramer 1976). Generally, larger values of CSI reflect lower buffering capacity. We grouped our samples into categories of CSI <1, 1-3, and >3 (Figure 6.) These categories were modified from Kramer (1976) and Glass and Loucks (1980). CSI <1 represents waters that are saturated or nearly saturated with respect to calcite and would not be susceptible to reduction in pH from acidic precipitation. Values of 1-3 represent waters that are potentially susceptible to acidification, and values of >3 are waters that are susceptible to acidification. Of the waters surveyed, 15% are not susceptible, 26% are potentially susceptible, and 59% are susceptible. The distribution of susceptible waters is very similar to that obtained from pH and alkalinity results. This is not surprising because CSI is calculated from both pH and alkalinity, as well as calcium. CSI was highly correlated with alkalinity (Figure 7). The regression equation was log alkalinity (µeq l$^{-1}$) = 3.42-0.39 CSI ($r^2$ = 0.929, $p$ <0.0001). The majority (59%) of the waters surveyed in New England were classed as sensitive to acidification, CSI >3. This proportion is very similar to that classed as sensitive on the basis of alkalinity alone (53% were alkalinity $\leq 200$ µeq l$^{-1}$).

Regional surveys that included measurement of Calcite Saturation Index are rare. Kramer (1981) calculated CSI with water chemistry data collected at road crossings over streams by a variety of workers in

Table 7. Regional Water Chemistry Survey Results for Surface Water Alkalinity Distribution. Alkalinity values are in μeq $l^{-1}$

| Location | Number | Percent in alkalinity range | | | | Reference |
|---|---|---|---|---|---|---|
| | | ≤20 | 21-100 | 101-200 | ≥201 | |
| | | Areas Where Precipitation Averages <pH 4.6 | | | | |
| New England | 226 | 23 | 18 | 12 | 47 | This Study |
| South Norway | 62 | 3 | 11 | 2 | 84 | Wright *et al*. 1977 |
| Denmark | 14 | 86 | 14 | 0 | 0 | Rebsdorf 1980 |
| Nova Scotia | 21 | 71 | 24 | 0 | 5 | Watt *et al*. 1979 |
| Central Ontario | 26 | 12 | 73 | 15 | 0 | Scheider *et al*. 1979 |
| Ontario | 600 | - | 16[a] | 32[b] | 52 | Zimmerman and Harvey 1979 |
| La Cloche Mountains | 4 | 100 | 0 | 0 | 0 | Beamish 1976 |
| Adirondack Mountains | 692 | 41 | 25 | 18 | 16 | Pfeiffer and Festa 1980 |
| | | Areas Where Precipitation Averages >pH 4.6 | | | | |
| Northwest Wisconsin | 265 | - | 15[c] | 17 | 68 | Lillie and Mason 1980 |
| North Minnesota | 85 | 0 | 22 | 26 | 52 | Glass and Loucks 1980 |

[a] ≤50 μeq $l^{-1}$
[b] 51 - 200 μeq $l^{-1}$
[c] ≤100 μeq $l^{-1}$

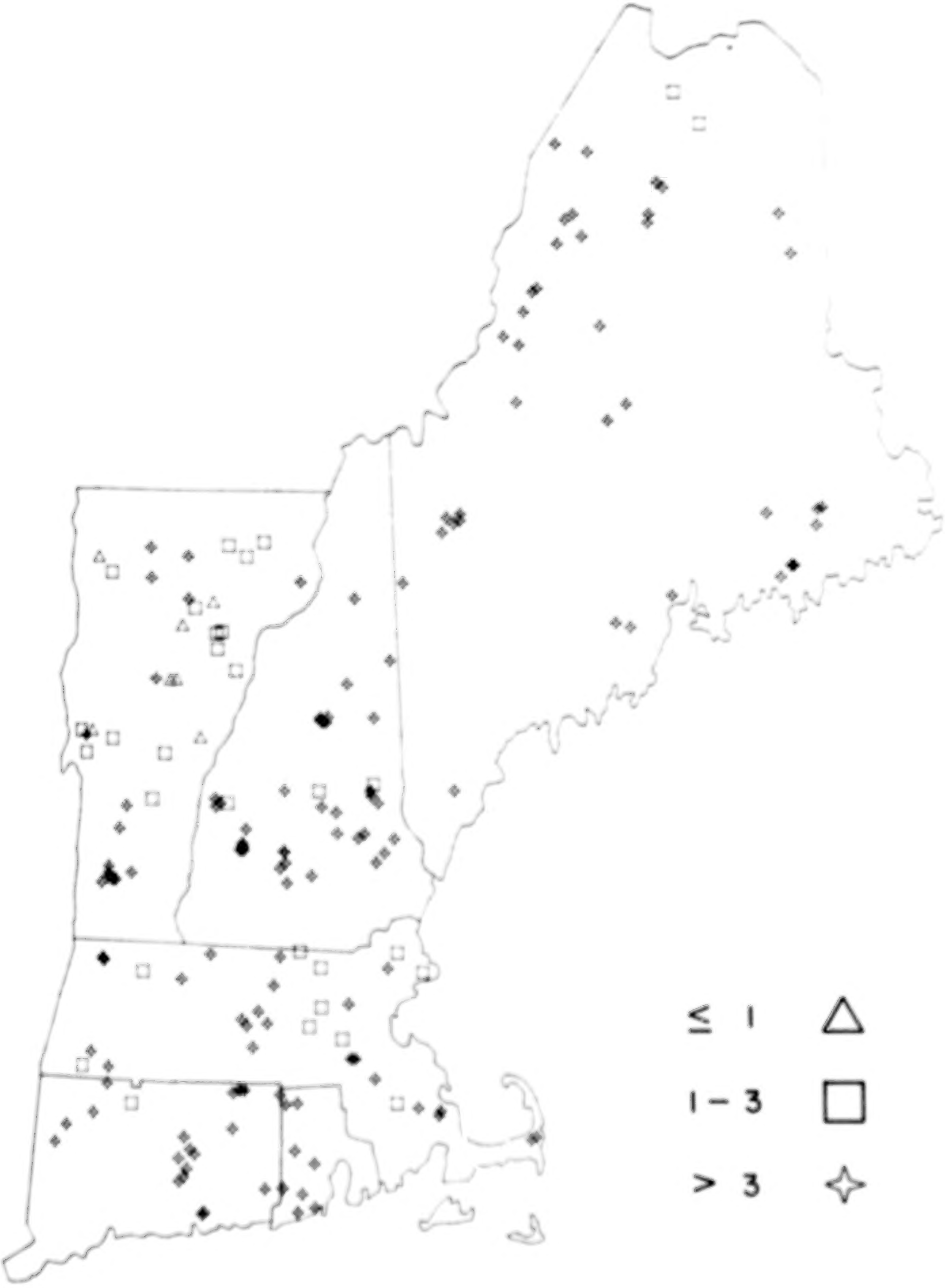

Figure 6. Map of New England showing the distribution of sample sites by Calcite Saturation Index (CSI). Data are for surface samples only, and are means of two replicates.

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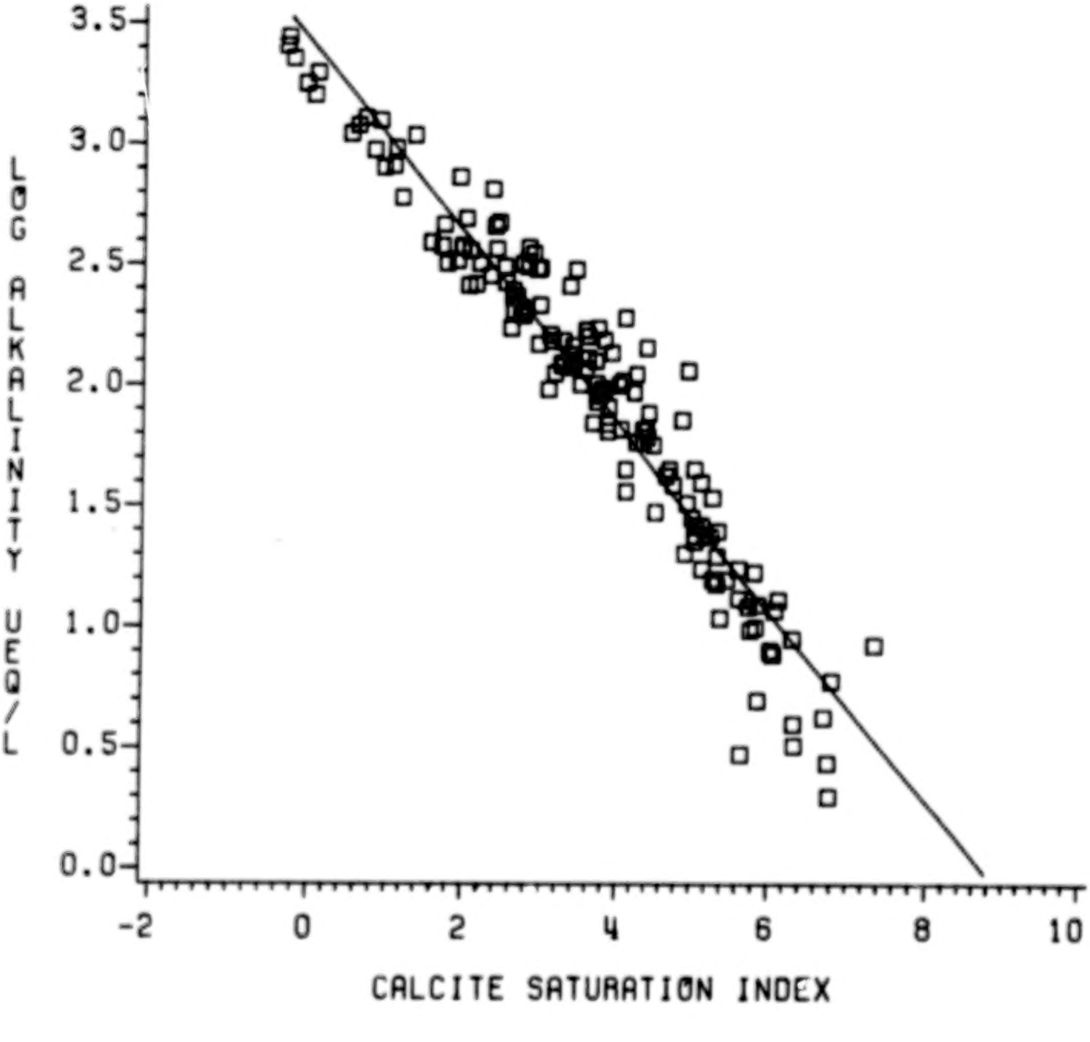

Figure 7. Relationship of alkalinity to Calcite Saturation Index for 195 New England lakes and streams. Data are means of two replicates and means of surface and deep samples where taken. Least squares regression equation: log Alk = 3.42 - 0.39 CSI ($\underline{r}^2$ = 0.929).

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eastern Canada. The data were presented as a contour map, and showed that portions of central and western Ontario had CSI values of 3 or more, and that most of Quebec and the Maritime Provinces had water with CSI greater than 3. Glass and Loucks (1980) calculated CSI for 85 lakes in northern Minnesota, an area that does not receive acidic precipitation. They found 11% had CSI <1, 53% had CSI of 1-3, and 36% were CSI >3. The distribution of New England headwater lakes and streams with respect to CSI indicates that many more are sensitive to acidification than in Minnesota (59% vs. 36%), and that the distribution may be similar to that in Ontario. However, CSI does not seem to provide any superior predictive ability to pH and alkalinity measurements, and represents an additional mathematical manipulation. Zimmerman and Harvey (1979) reached a similar conclusion for surface waters in Ontario.

Ionic Composition

Specific conductance is an index of total ionic content of water, and thus has potential for use as a simple index of buffering capacity. However other factors, such as distance from seacoast and differences in ion activities, also affect specific conductance, limiting its usefulness for this purpose. As a result, the relationship between specific conductance and alkalinity (Figure 8), although statistically significant, is not especially strong ($r^2 = 0.71$). Some waters that are high in specific conductance are low in alkalinity. In some cases this represents increased hydrogen ion content, which has very high equivalent conductance (Weast 1978). In other cases it represents marine aerosol input, or unusual minerology such as gypsum.

Chloride was measured for use in correction of other ions for marine aerosol contribution, and is a possible indicator of human disturbance. The relation of chloride to distance from the sea coast (shortest straight line) is given in Figure 9. The influence of marine aerosols close to the coast is evident, with high chloride concentrations close to the coast falling off very sharply at 75 to 100 km to background concentrations of less than 50 $\mu$eq $l^{-1}$. This is almost identical to the situation in south Norway (Wright and Henriksen 1978), and Scotland (Wright and Henriksen 1980). There are four waters with anomalously high chloride concentrations. These four waters also were ranked high in human disturbance. However, there were many other sites that were also ranked high in human disturbance that could not be identified on the basis of high chloride concentration. As chloride concentration was almost entirely related to marine aerosols, it was used to correct other ions for marine aerosols contribution. Chloride was not used as an index of human disturbance.

Ionic composition of the surface waters, corrected for marine aerosols, varies markedly with pH (Figure 10). Total ionic content is highest at high pH and declines with successively lower pH. Of the anions, bicarbonate decreases markedly below pH 6 and is absent below pH 5, as expected. However, although sulfate composes a larger

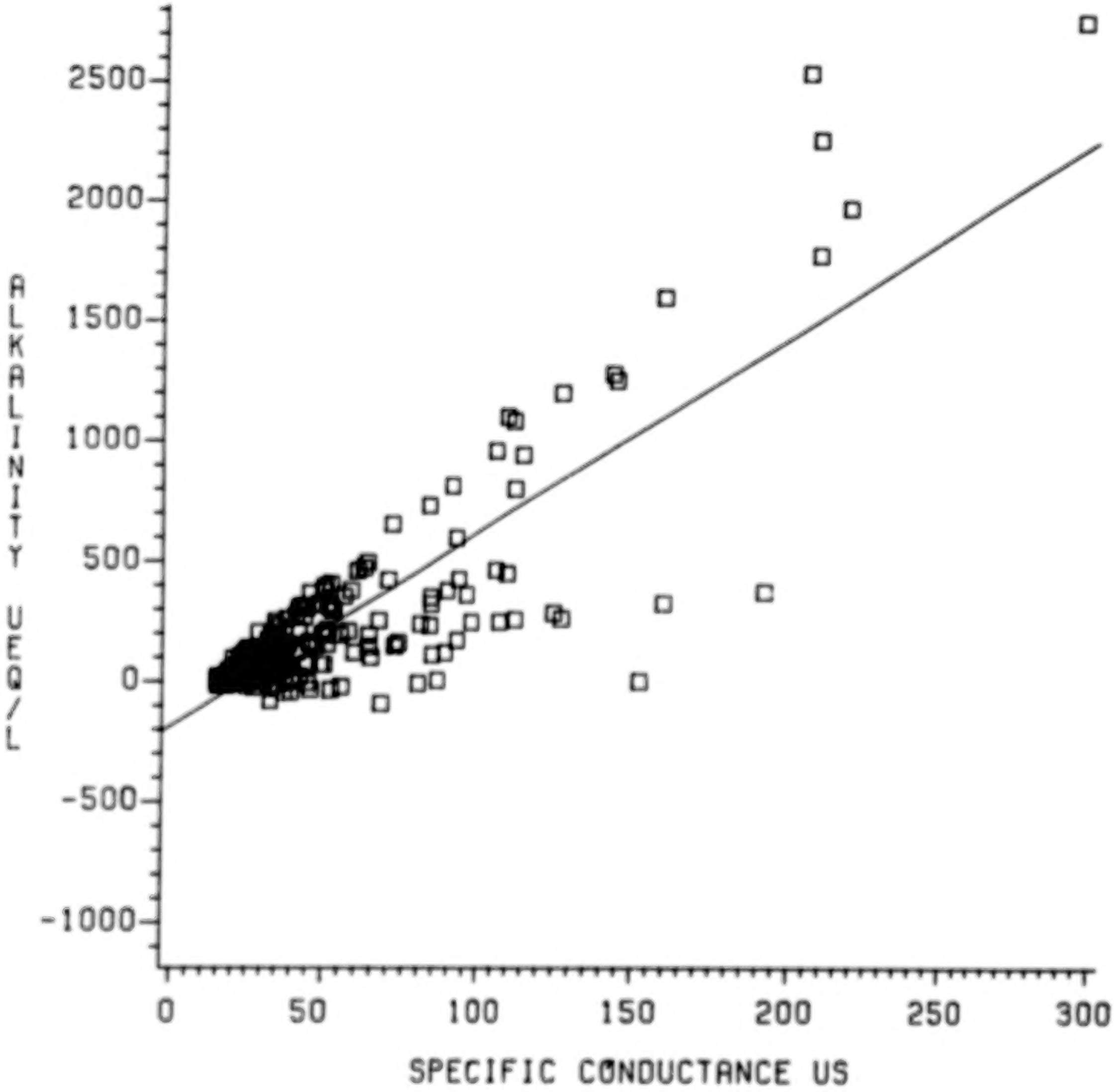

Figure 8. Relationship between alkalinity and specific conductance for 195 New England lakes and streams. Data are means of two replicates and means of surface and deep samples where taken. Least squares regression equation: Alk = -185 + 8.06 Sp. Cond. ($\underline{r}^2$ = 0.711).

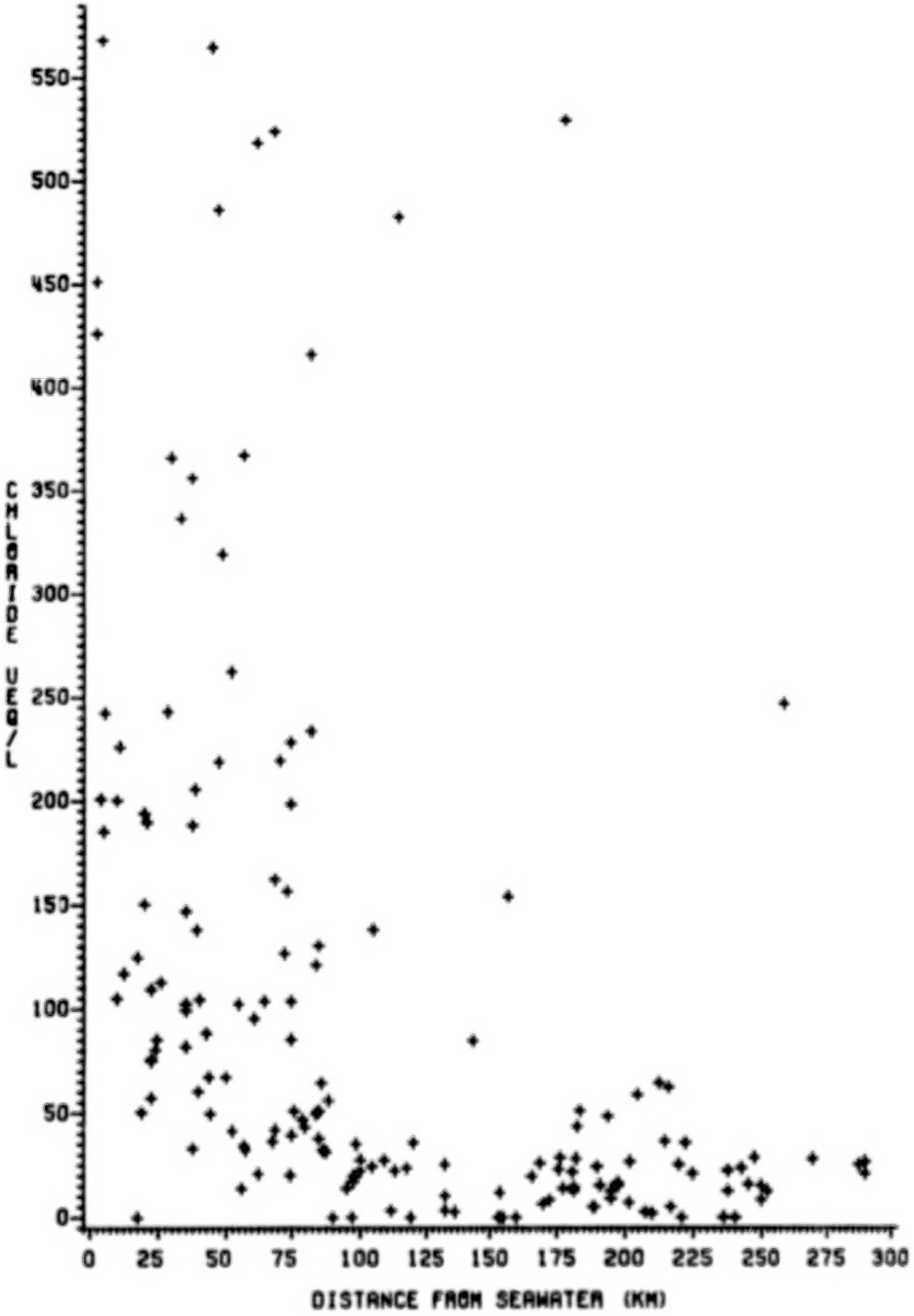

Figure 9. Relationship of chloride concentration to distance from seawater for 184 New England lakes. Chloride data are means of two replicates and means of surface and deep samples where taken. Distance from seacoast is the shortest straight line to open ocean.

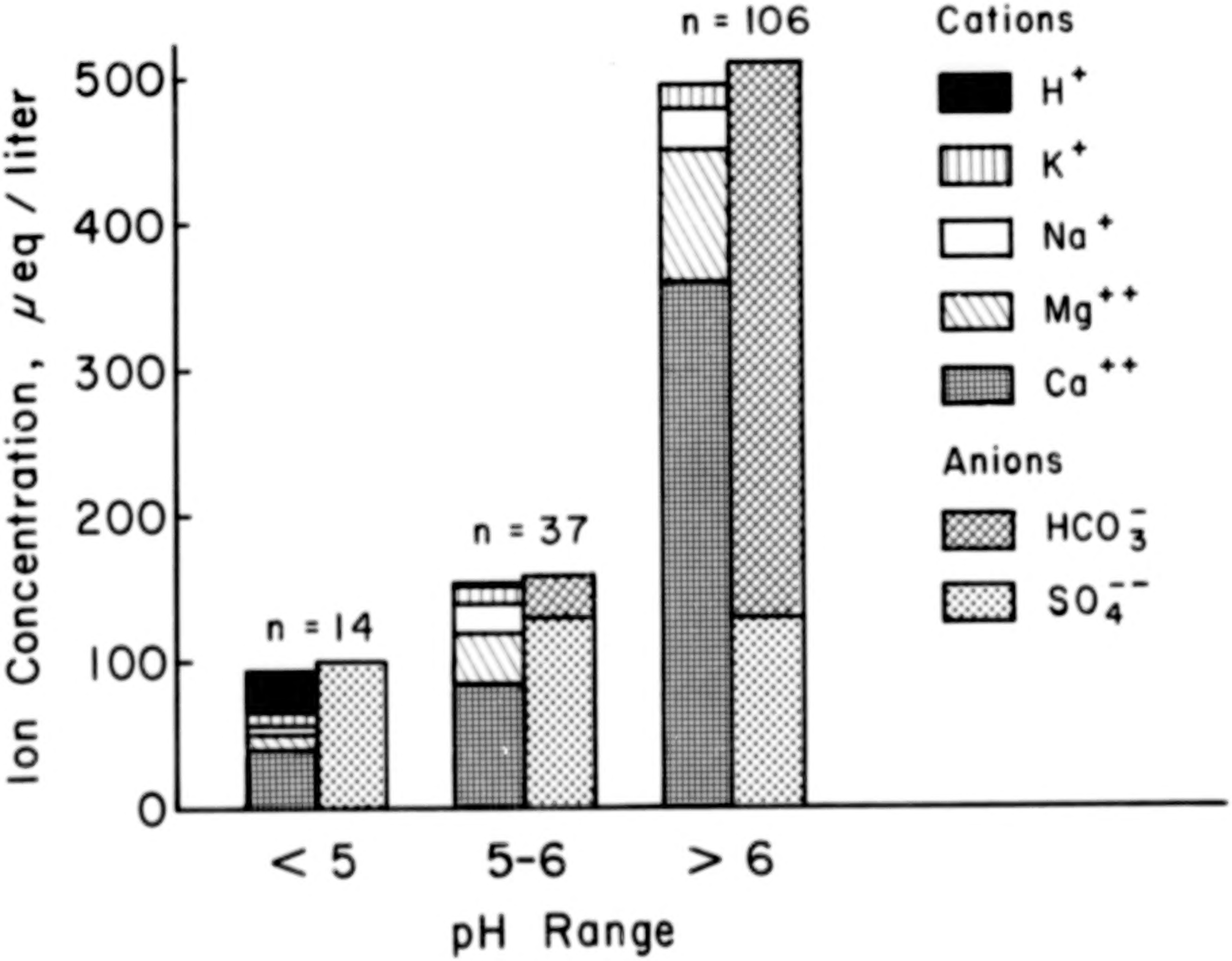

Figure 10. Distribution of major ions in New England lakes and streams classed according to pH range.

proportion of total anions as pH declines, the concentration of sulfate does not change appreciably. Of the cations, hydrogen ion increases as pH declines, as expected, calcium and magnesium decline markedly, and sodium and potassium decline moderately. The present composition of cations and anions is compared to world averages in Table 8. High pH New England lakes have anion distribution similar to the world averages, but a somewhat larger proportion of calcium and magnesium.

The mean total ionic content of the surface waters surveyed was about 1,000 $\mu$eq l$^{-1}$ at pH>6, 300 $\mu$eq l$^{-1}$ at pH 5-6, and 200 $\mu$eq l$^{-1}$ at pH<5 (Figure 10). Henriksen (1980) summarized ion composition data for 13 surveys of areas unaffected by acidic precipitation. Mean total ionic content ranged from 200 to 2,300 $\mu$eq l$^{-1}$, but in 11 of the 13 surveys the mean was less than 800 $\mu$eq l$^{-1}$. There was no apparent difference in ionic strength of acidic New England lakes and non-acidic softwater lakes elsewhere in the world.

Sulfate

Virtually all of the sulfate in the New England lakes and streams surveyed is from non-marine sources. One lake, Holts Pond, Massachusetts, had an extremely high sulfate concentration (mean of surface and deep samples, replicated = 44 mg l$^{-1}$ 915 $\mu$eq l$^{-1}$). The sulfate was nearly balanced by calcium (mean 16.3 mg l$^{-1}$, 815 $\mu$eq l$^{-1}$), indicating that this lake was most likely influenced by a local deposit of gypsum, and it was not included in sulfate analysis. For the remaining waters, the $SO_4$: Cl ratio (Figure 11) shows that most samples exceeded the ratio of these ions in seawater (0.10), especially those located more than 75 km from the seacoast where marine aerosols are relatively unimportant. This indicates a non-marine source of sulfate. As further evidence of this, total sulfate concentration is independent of chloride concentration (Figure 12). The $SO_4$: Cl ratios are higher than those reported for south Norway. Wright and Henriksen (1978) report $SO_4$: Cl ratios 3-20 times higher than in seawater. In the lakes we surveyed the ratios were as much as 70 times higher than seawater, and 40% of the lakes had ratios exceeding 20 times that in seawater.

The concentrations of total and non-marine sulfate found in New England lakes are comparable to those found in other regions where precipitation is acidic, and are much higher than in areas where precipitation is not acidic (Table 9). However, contrary to the situation in south Norway, non-marine sulfate content was not positively correlated with hydrogen ion content in waters with low (<100 $\mu$eq l$^{-1}$) calcium content (Figure 13). Brown and Sadler (1981), using the data of Wright and Snekvik (1978), found a highly significant correlation in 471 lakes in south Norway ($r^2$ = 0.354, *p* <0.0001), even though they did not stratify the lakes by calcium concentration. Brown *et al.* (1980), using the same data, also found significant positive correlations between non-marine sulfate and calcium, and calcium plus magnesium, in addition to hydrogen ion. These correlations were low in New England,

Table 8. Percent Relative Distribution of Major Ions in New England Headwater Lakes and Streams as Compared with World Averages, Corrected for Marine Aerosols. Ion Concentrations are $\mu eq\ l^{-1}$

| Ions | World averages[a] | | | New England | | |
|---|---|---|---|---|---|---|
| Cations | Clark 1924 | Livingstone 1963 | Rodhe 1949 | pH <5 | pH 5-6 | pH >6 |
| Ca + Mg | 88.2 | 87.9 | 88.6 | 79.5 | 79.9 | 91.0 |
| Na + K | 11.8 | 12.1 | 11.4 | 20.5 | 20.1 | 9.0 |
| Anions | | | | | | |
| $HCO_3$ | 83.0 | 82.0 | 83.0 | 0 | 15.4 | 74.8 |
| $SO_4$ | 17.0 | 18.0 | 17.0 | 100 | 84.6 | 25.2 |

[a] After Henriksen (1980)

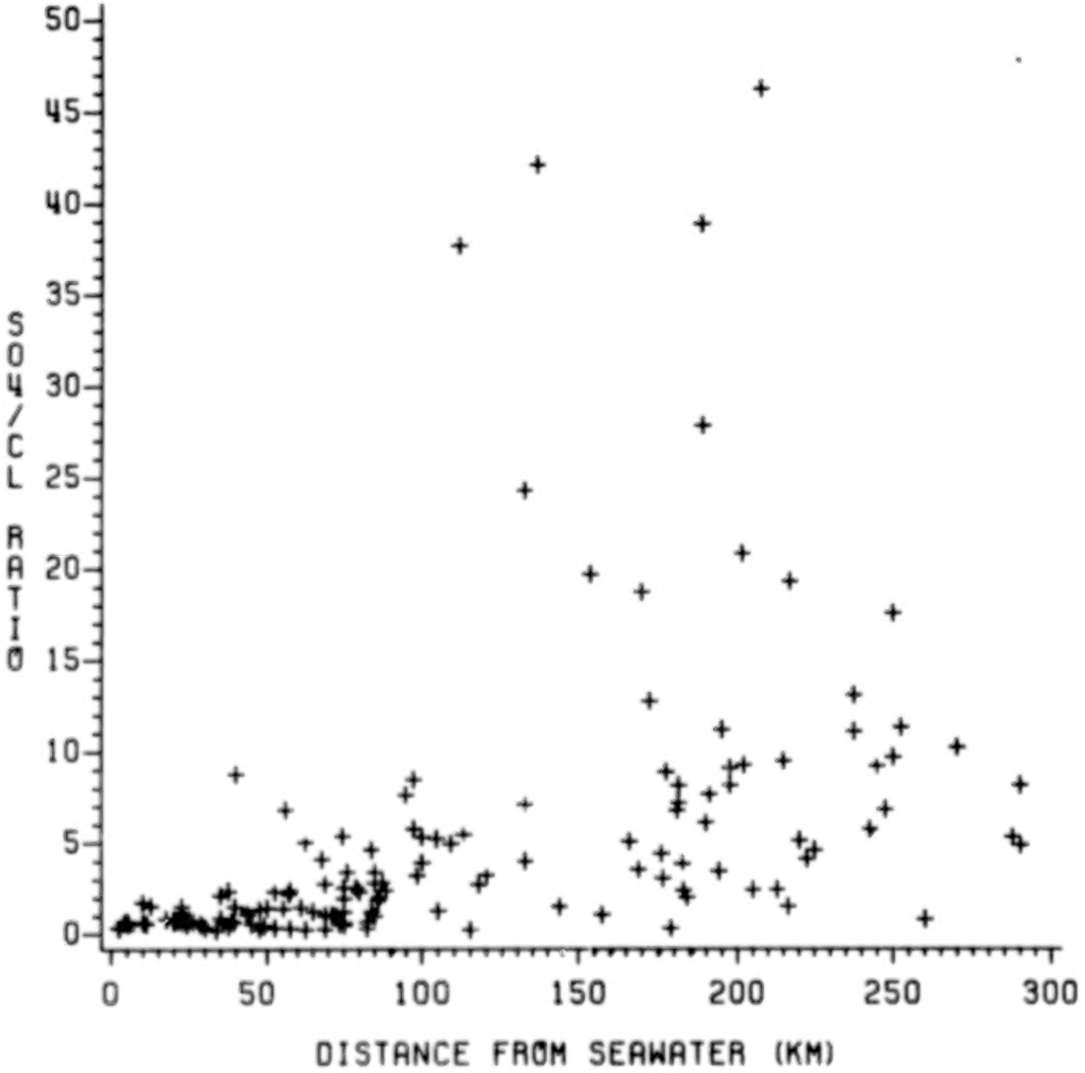

Figure 11. Sulfate: chloride ratio versus distance from seacoast for 184 New England lakes. Sulfate and chloride are means of two replicates and means of surface and deep samples where taken. Distance from seacoast is shortest straight line to open ocean.

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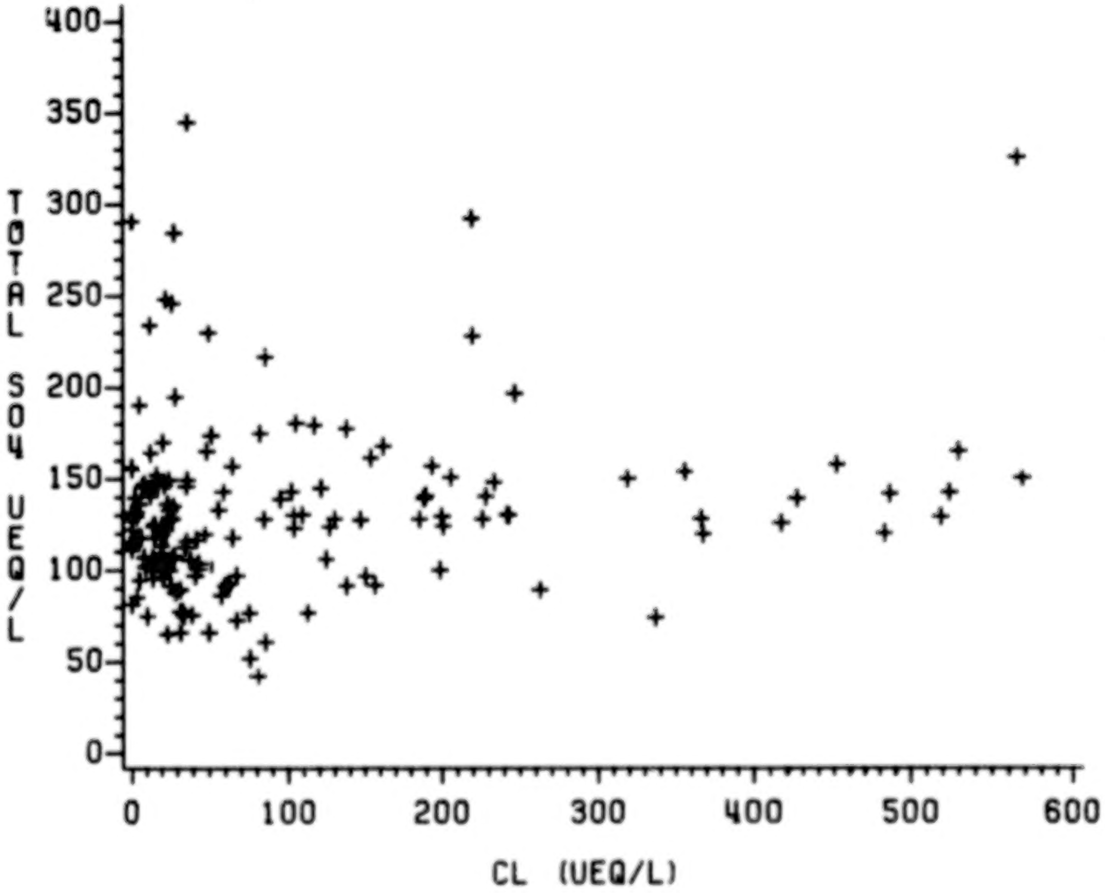

Figure 12. Relationship of sulfate concentration to chloride concentration. Sulfate is total concentration, not corrected for marine aerosols. Data are for 184 New England lakes, are means of two replicates, and are means of surface and deep samples where taken.

Table 9. Amount of Sulfate ($\mu eq\ l^{-1}$) Found in Surface Waters in Regional Water Chemistry Surveys

| Region | N | Total sulfate | | Non-marine sulfate | | Reference |
|---|---|---|---|---|---|---|
| | | $\bar{X}$ | S.D. | $\bar{X}$ | S.D. | |
| | Areas Where Precipitation Averages <pH 4.6 | | | | | |
| New England | 226 | 138 | 51 | 127 | 48 | This Study |
| South Norway | 26 | 99 | 33 | 92 | - | Gjessing *et al*. 1976 |
| West Sweden | 6 | 200 | 70 | 180 | - | Grahn *et al*. 1974 |
| Scotland | 72 | 178 | 91 | 148 | 76 | Wright and Gjessing 1976 |
| Nova Scotia | 16 | 152 | 28 | 117 | 25 | Watt *et al*. 1979 |
| Central Ontario | 15 | 198 | 97 | - | - | Dillon *et al*. 1978 |
| Sudbury, Ontario | 4 | 804 | 292 | 800 | 290 | Scheider *et al*. 1975 |
| Le Cloche Mountains | 4 | 287 | 42 | 285 | 41 | Beamish 1976 |
| | Areas Where Precipitation Averages >pH 4.6 | | | | | |
| Central Norway | 52 | 65 | 34 | 63 | - | Gjessing *et al*. 1976 |
| Western Ontario | 7 | 63 | - | 58 | - | Armstrong and Schindler 1971 |

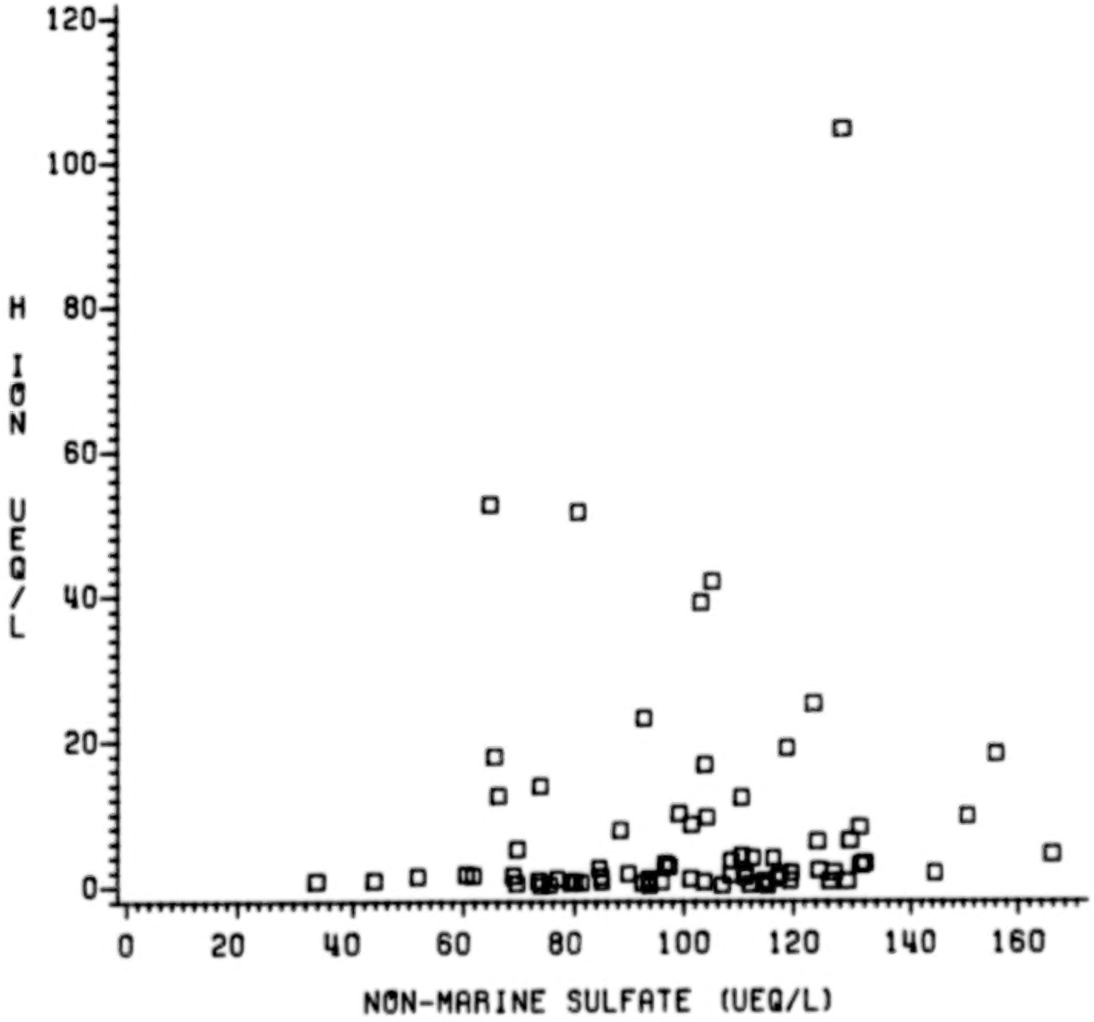

Figure 13. Relationship of hydrogen ion to non-marine sulfate concentration for 72 New England waters with calcium <100 $\mu$eq $l^{-1}$. Data are means of two replicates and means of surface and deep samples where taken. The linear regression was not significant ($\underline{r}^2$ = 0.047, $\underline{p}$ = 0.12).

$r^2$ = 0.096 and 0.070, respectively. In our samples, high calcium waters had significant bicarbonate ion whereas low calcium waters were lacking in bicarbonate and sulfate was the major anion. The lack of correlation between surface water pH and non-marine sulfate content may result from the fact that precipitation throughout the region is relatively uniform in chemistry (National Atmospheric Deposition Program 1981) unlike Scandinavia, except for the relationship between marine aerosols and distance from the seacoast. Waters receive relatively uniform amounts of non-marine sulfate deposition, but only some lakes become acidic as the result of low buffering capacity.

Another possible explanation is that there is a regional "background" level of sulfate, in addition to marine aerosols, that masks the sulfate associated with acid. Background sulfate could originate from terrestrial dusts or anthropogenic sulfate that is not acidic. Wright (Richard Wright, Norwegian Institute of Water Research, personal communication) has proposed that a proportion of non-marine sulfate equivalent to the sum of non-marine sodium plus potassium be subtracted as a correction for background sulfate. Background sulfate calculated by this method averages 50 µeq/$l^{-1}$ for New England. Background sulfate content of a lake should be independent of ionic strength if it is truly of regional character. However because of the principal of ionic balance there will probably be some relationship between background sulfate and total ionic strength. Background sulfate calculated from our data is correlated with total cations (Figure 14), but the slope is very close to zero. Using 50 µeq $l^{-1}$ as the best estimate of regional background sulfate, net non-marine sulfate was calculated and compared to hydrogen ion (Figure 15). The relationship is no better than that obtained with non-marine sulfate.

### Calcium and Magnesium

Calcium and magnesium were highly correlated with alkalinity ($r^2$ = 0.951, $p < 0.0001$; Figure 16). The regression equation is Alkalinity (µeq $l^{-1}$) = -55 + 0.95 (non-marine Ca + Mg, µeq $l^{-1}$). This compares favorably with the equation Alkalinity (µeq $l^{-1}$) = -14 + 0.93 (non-marine Ca + Mg, µeq $l^{-1}$) $r^2$ = 0.98 obtained by Henriksen (1980) based on 13 sets of data from areas that are relatively unaffected by acidic precipitation. The slopes are very similar but the intercept is lower for our data. This suggests that acidic precipitation has not affected the proportional relationship of calcium plus magnesium to alkalinity in New England, although alkalinity may be reduced generally. In contrast to this, Almer *et al*. (1978) reported that the relationship between these factors was nearly 1:1 in an area of Sweden that received a small sulfur load, but much less than 1:1 in an area that received a higher sulfur loading. Sulfur loading is relatively uniform over New England (National Atmospheric Deposition Program 1981).

Acidic lakes tend to be lower in calcium than comparable non-acidic lakes. Almer *et al*. (1974) found that calcium plus magnesium content

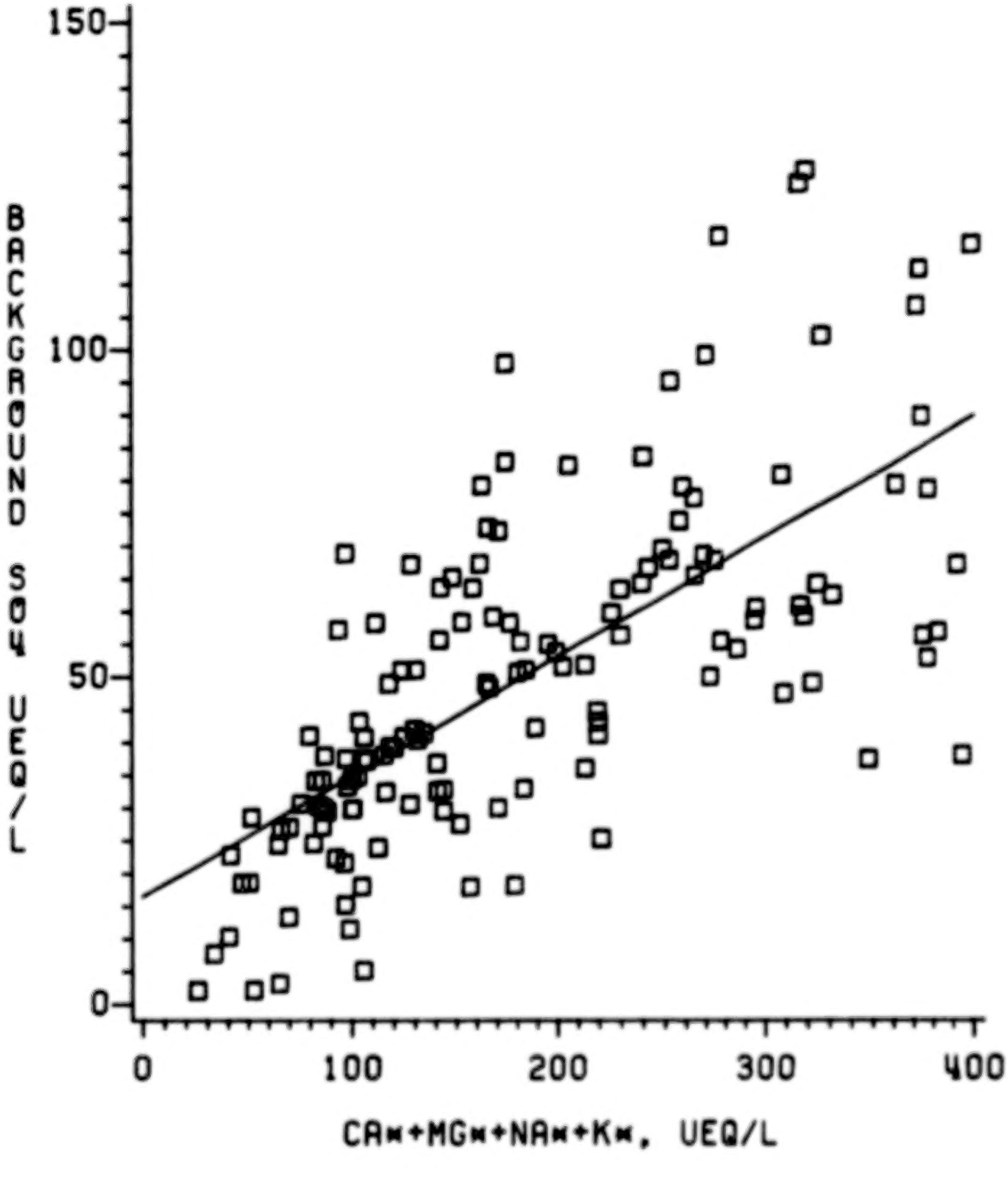

Figure 14. Relation of calculated background sulfate concentration to the sum of cations for 168 lakes. Lakes with non-marine sulfate or calcium plus magnesium concentration exceeding 400 μeq $l^{-1}$ were eliminated. The regression equation is BSU = 0.26 cations - 3.49, $\underline{r}^2$ = 0.52, $\underline{p}$ = 0.0001, computed from means of two replicates and means of surface and deep samples where taken.

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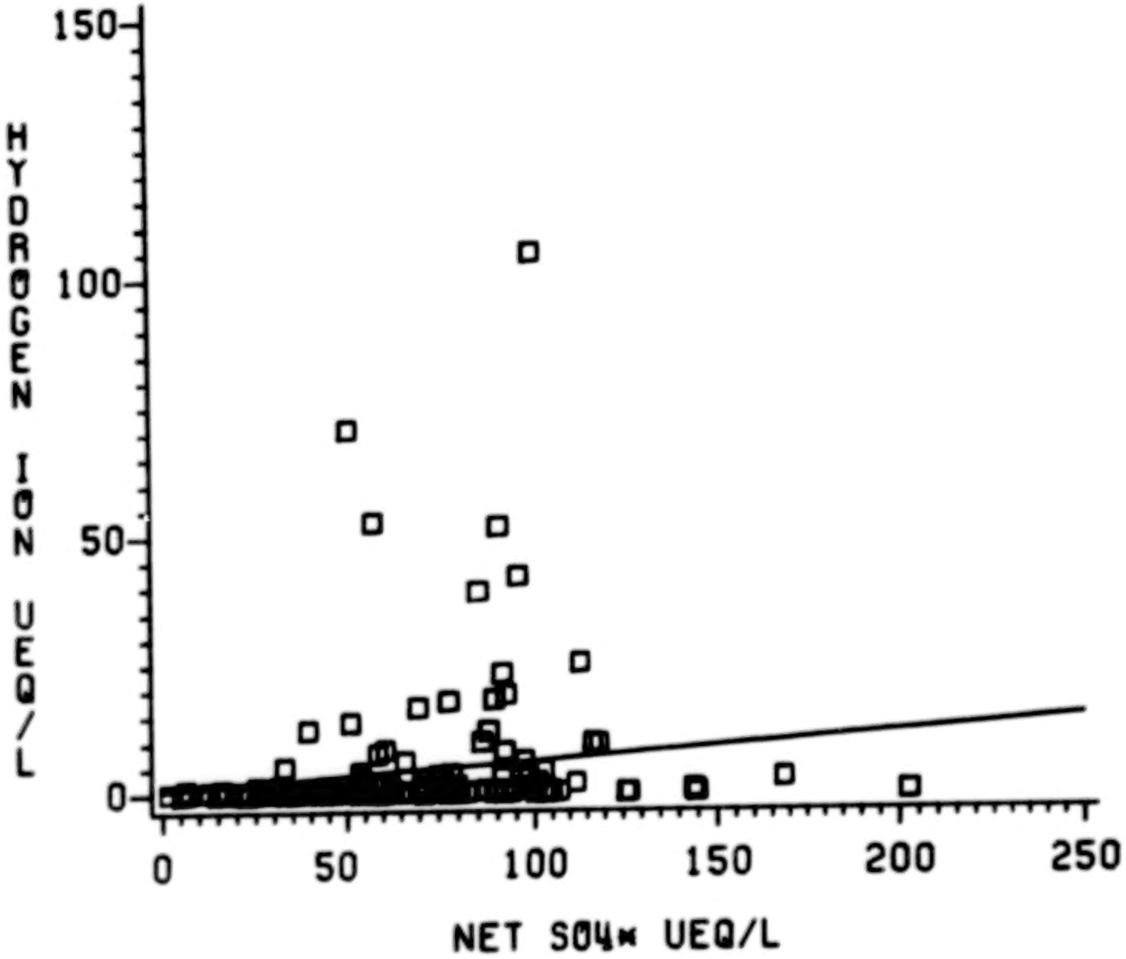

Figure 15. Relation of hydrogen ion to net non-marine sulfate concentration. The regression equation is H ion = 3.24 + 0.02 net sulfate, $\underline{r}^2$ = 0.006, not significant.

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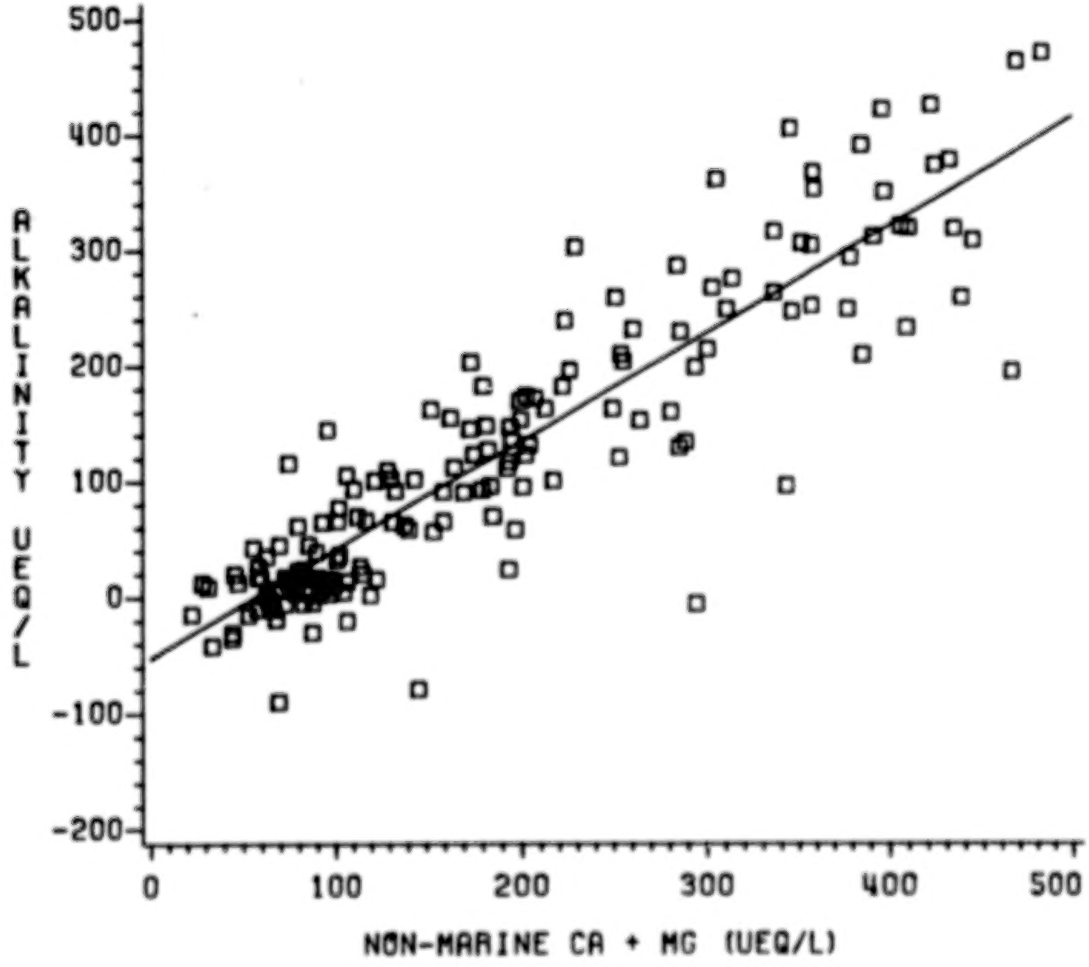

Figure 16. Relationship of alkalinity to non-marine calcium plus magnesium for 226 surface waters in New England. Data are means of two replicates and means of surface and deep samples where taken. Least squares regression equation:
Alk = -53 + 0.93 (Ca+Mg) ($\underline{r}^2$ = 0.948).

increased from 290 μeq $1^{-1}$ in Swedish lakes of pH 4.9 or less to 820 μeq $1^{-1}$ in lakes with pH 7.0 or more. Gjessing et al. (1976) reported that lakes in south Norway with median pH 4.76 had mean calcium content of 57 μeq $1^{-1}$ whereas lakes in central Norway with median pH 6.40 had mean calcium content of 139 μeq $1^{-1}$. The explanation for this is that areas that receive acidic precipitation contain both well buffered and poorly buffered waters, depending on the chemical content of bedrock and soil. Well buffered waters contain proportionally larger amounts of calcium and bicarbonate, which is of geological origin, than poorly buffered waters. Only the poorly buffered waters will be acidified, and therefore acidic waters will be lower in calcium than non-acidic waters in the same area. Mohn et al. (1980) concluded that headwater lakes in south Norway that were low in calcium, and therefore in buffering capacity, had water concentrations of hydrogen and sulfate ion that were significantly related to precipitation chemistry. Precipitation chemistry in the New England region is relatively uniform, and this relationship cannot be tested.

## Aluminum and Manganese

Aluminum concentration was related to pH (Figure 17), with high aluminum concentrations generally found in low pH waters, as expected. The regression equation is $\log_{10}$ Al (μg $1^{-1}$) = 3.93 - 0.36 pH and the correlation coefficient is significant ($r^2 = 0.37$, $p < 0.001$). Eighteen of 226 samples (8%) had aluminum concentrations of 200 μg $1^{-1}$ or higher, the highest being 510 μg $1^{-1}$. These waters were distributed in the same areas as low pH waters (Figure 18). Forty-seven samples (21%) had aluminum concentrations of 100 μg $1^{-1}$ or more. There were 13 sample sites that had an aluminum concentration of 200 μg $1^{-1}$ or more and a pH of 5.5 or less. These conditions may be toxic to some species of fish (Schofield and Trojnar 1980).

The relationship between aluminum and pH found in New England is very similar to that found in lakes in Sweden (Dickson 1975, 1980), Norway (Wright and Gjessing 1976), Scotland (Wright and Henriksen 1980), and New York (Schofield 1982), as shown in Table 10. Schofield and Trojnar (1980) made multiple measurements of pH and aluminum concentration in one stream in New York and found a similar relationship to that found in the regional surveys cited above (Table 10). This suggests that the relationship is an expression of the thermodynamic equilibrium of aluminum and hydrogen ion, enabling the prediction of aluminum concentration from pH in any region.

Manganese is only slightly related to pH (Figure 19). Manganese generally was found in lower concentrations than aluminum, and there is more variability in the manganese: pH relationship ($r^2 = 0.015$; $p > 0.05$). The reason for this variability is unknown.

## Organic Acids

Color was measured as an index of organic acids. Color was highly correlated with total organic carbon (TOC) determinations performed on a

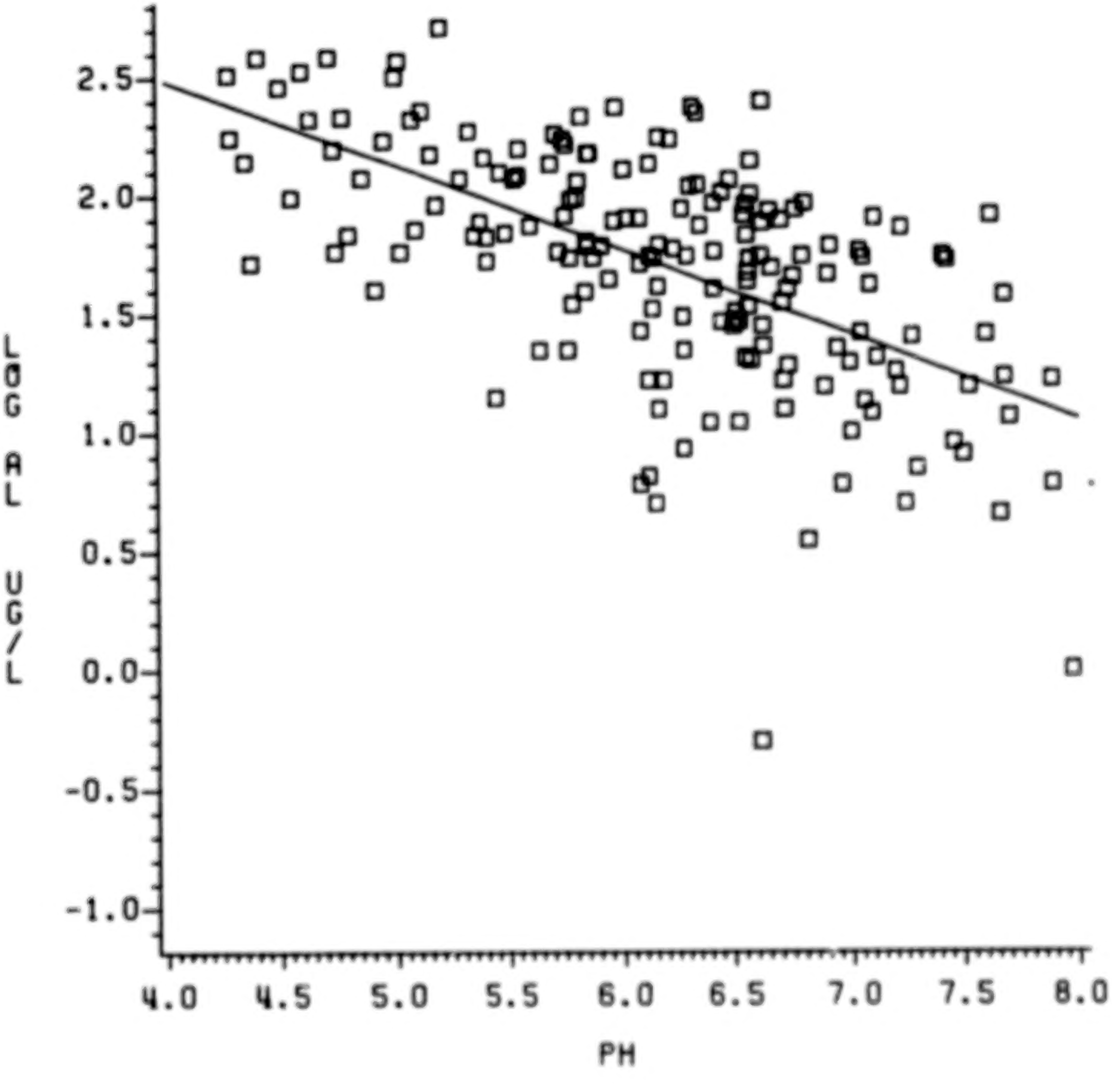

Figure 17. Relationship of total aluminum concentration to pH. The pH data are means of two replicates, and both pH and aluminum are means of surface deep samples where taken. Least squares regression equation:
log Al = 3.93 - 0.36 pH ($\underline{r}^2$ = 0.37).

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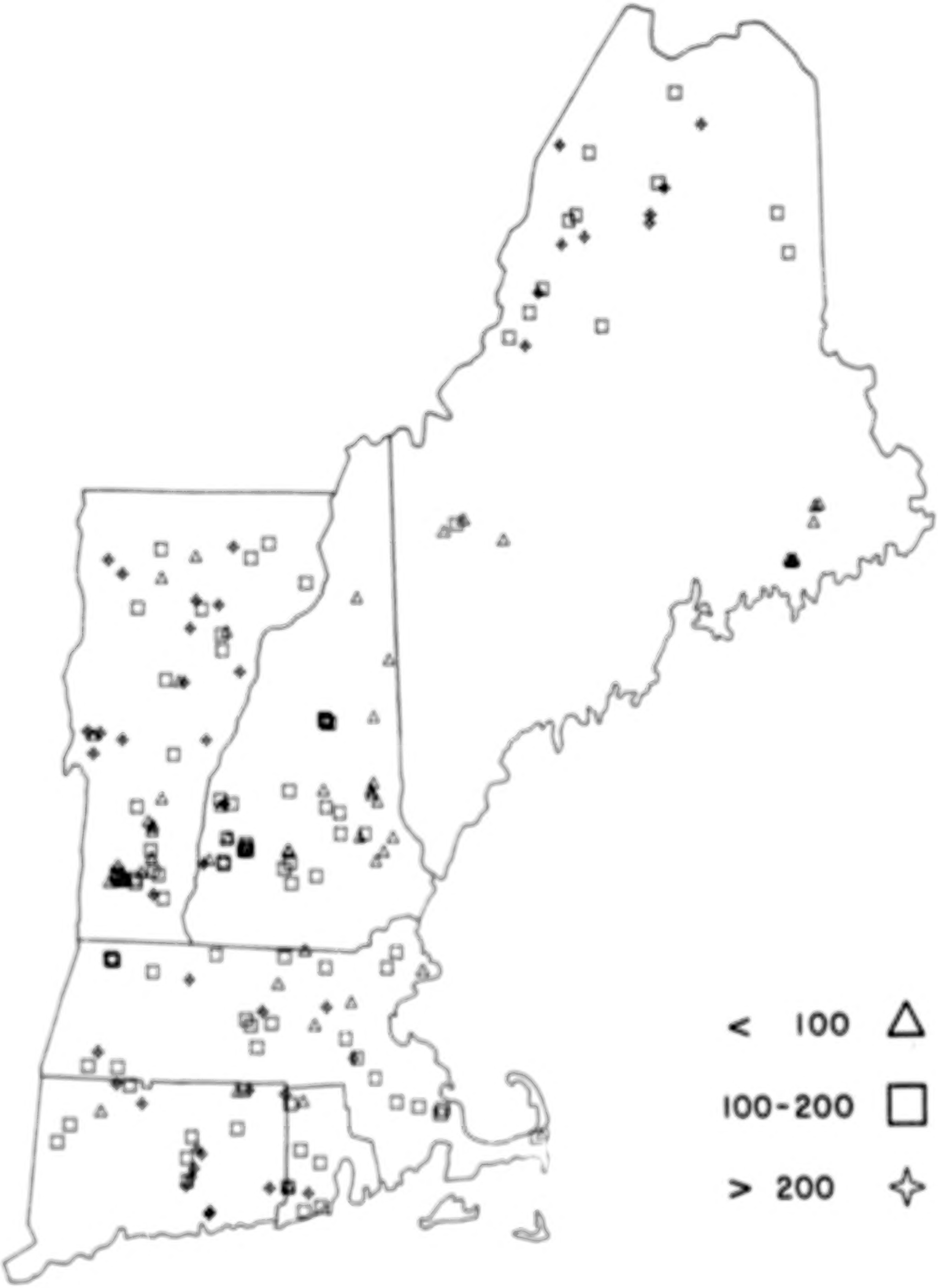

Figure 18. Map of New England showing location of sample sites grouped by aluminum concentration ($\mu g\ l^{-1}$). Data are for surface samples only.

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Table 10. Values for the Intercept (A) and Slope (B) for the Linear Regression of Total Aluminum and pH. $\text{Log}_{10}$ ($\mu g\ l^{-1}$) = A + B (pH), from Regional Water Chemistry Surveys

| Location | N | Intercept | Slope | Reference |
|---|---|---|---|---|
| New England | 226 | 3.93 | -0.36 | This Study |
| Sweden | 37 | 3.85 | -0.35 | Dickson 1975 |
| Sweden | 73 | 3.94 | -0.38 | Dickson 1980 |
| Norway | 47 | 3.85 | -0.41 | Wright and Gjessing 1976 |
| New York | 214 | 4.14 | -0.33 | Schofield 1982 |
| New York | 68[a] | 3.97 | -0.87 | Schofield and Trojnar 1980 |

[a] Acid Brook, measured 68 times from March to August.

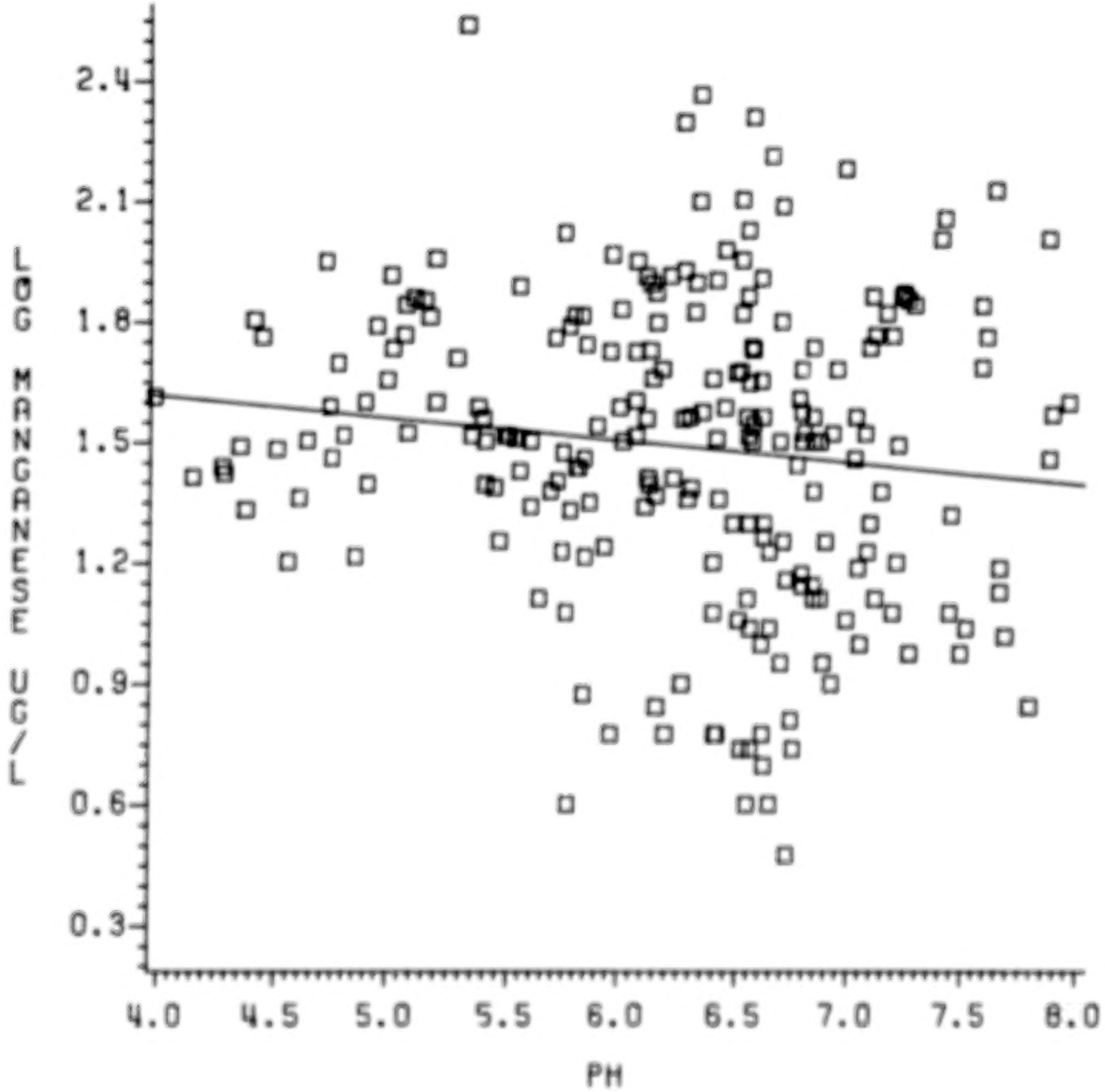

Figure 19. Relationship of manganese to pH for 195 New England surface waters. The pH data are means of two replicates, and both pH and manganese are means of surface and deep samples where taken. Least squaress regression equation:

$\log Mn = 1.83 - 0.05\ pH$ ($\underline{r}^2 = 0.015$).

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set of 31 samples ranging in color from 0 to 260 units. The regression equation was TOC (mg $l^{-1}$) = 1.32 + 0.0613 color (color unit), and $r^2$ = 0.902. This equation was used to calculate TOC values for all samples. This relationship agrees well with the approximation TOC = color ÷ 10 used by the Norwegian Institute for Water Research (R. Wright, personal communication).

A plot of color or $\log_{10}$ TOC versus pH (Figures 20,21) shows no relationship between these factors. Although we attempted to avoid highly colored waters in the selection of sampling sites, a few were included. On some occasions water turned out to be more colored than we realized when the sample was collected. In other cases a colored water was sampled if there were no obvious bog characteristics and we needed a sample in that area. The lack of relationship between pH and color (or TOC) suggests that the acidic lakes are not the result of organic acids. Similarly, there was little relationship between alkalinity and color (Figure 22). Only 16 samples had alkalinity of more than 500 $\mu$eq $l^{-1}$, and these all had color less than 40 units. The remaining 210 waters showed no relationship between alkalinity and color. There is no evidence of increased buffering capacity (alkalinity) contributed by organic acids in highly colored waters, as was reported by Johannessen (1980) for humic lakes in Norway.

Driscoll et al. (1980) reported that aluminum formed strong complexes with organic ligands. It is therefore possible that changes in total organic carbon, which are independent of pH, could account for some of the variation in aluminum concentration in the waters surveyed. A comparison of aluminum and total organic carbon concentrations (Figure 23) indicates that this relationship is not significant ($r^2$ = 0.17).

### Precipitation Chemistry

To successfully correlate surface water and precipitation chemistry, a large region of highly uniform geology and climate with strong gradients in precipitation chemistry would be required. Such a situation exists in Scandinavia (Wright and Gjessing 1976), but not in New England. As a result, attempts to relate surface water chemistry to precipitation chemistry were unsuccessful. Chemistry of precipitation in New England, as reported by the National Atmospheric Deposition Program (1981), is relatively uniform. The small differences in annual deposition of hydrogen ion over the region are far outweighed by differences in surface water chemistry resulting from watershed interations, bedrock type, soil type, etc.

## PHYSICAL FACTORS THAT AFFECT WATER CHEMISTRY

### Elevation

Surface water pH was only weakly related to elevation (Figure 24). Some very acidic lakes are located at elevations below 100 m, and lakes

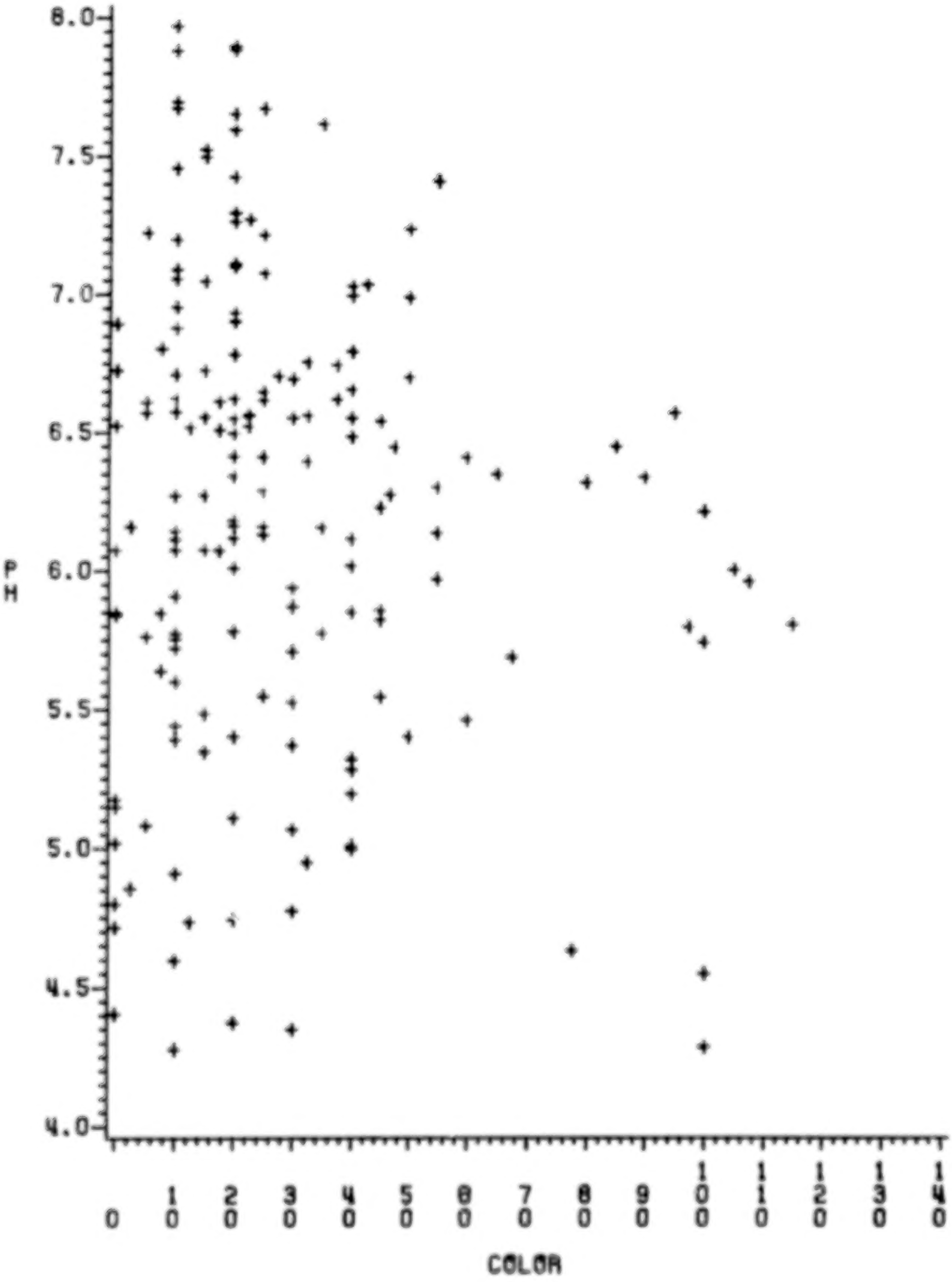

Figure 20. Relationship of pH to apparent color. Data are means of two replicates and means of surface and deep samples where taken.

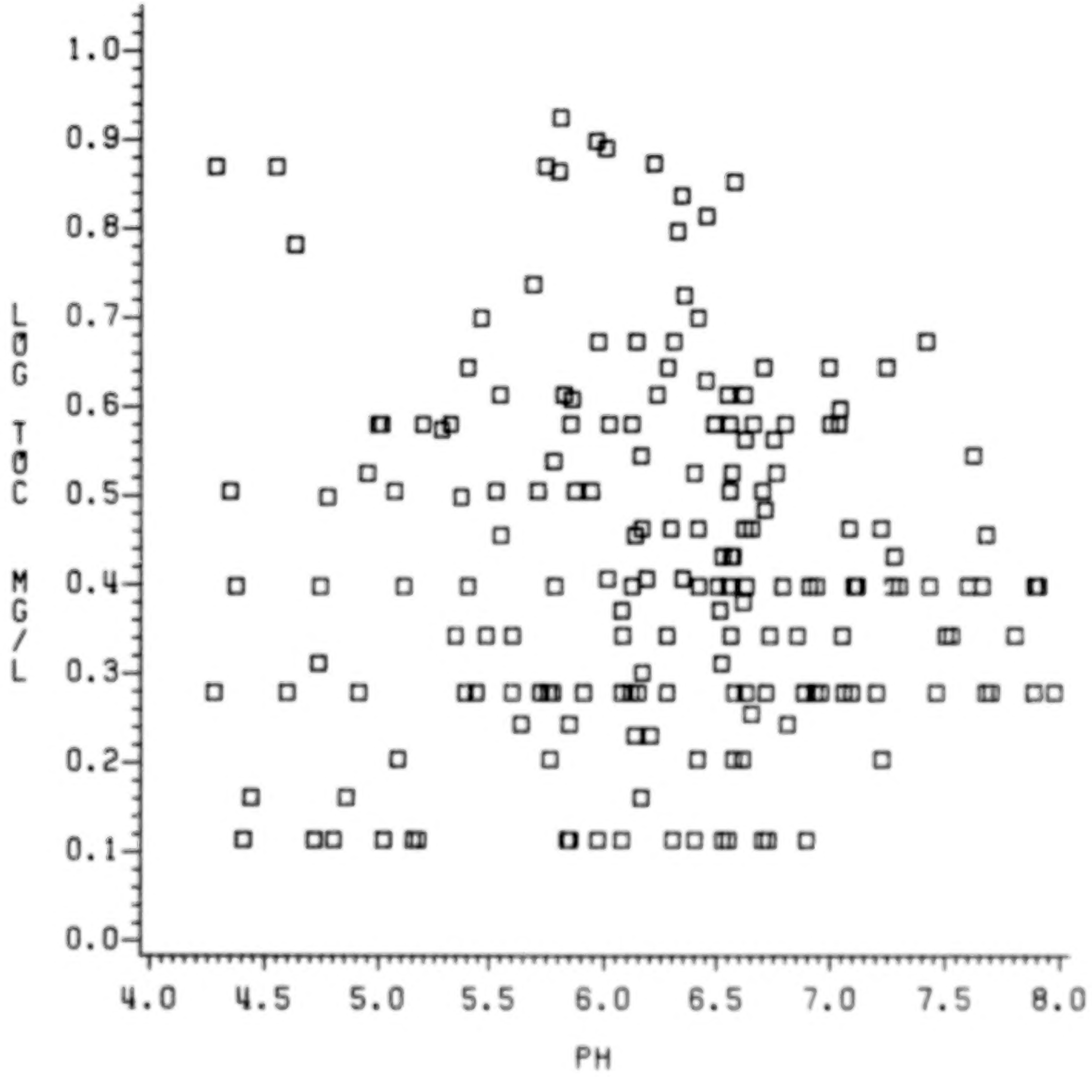

Figure 21. Relationship of total organic carbon (TOC) to pH. TOC was calculated from color by the equation:
TOC = 1.32 + 0.0613 color.

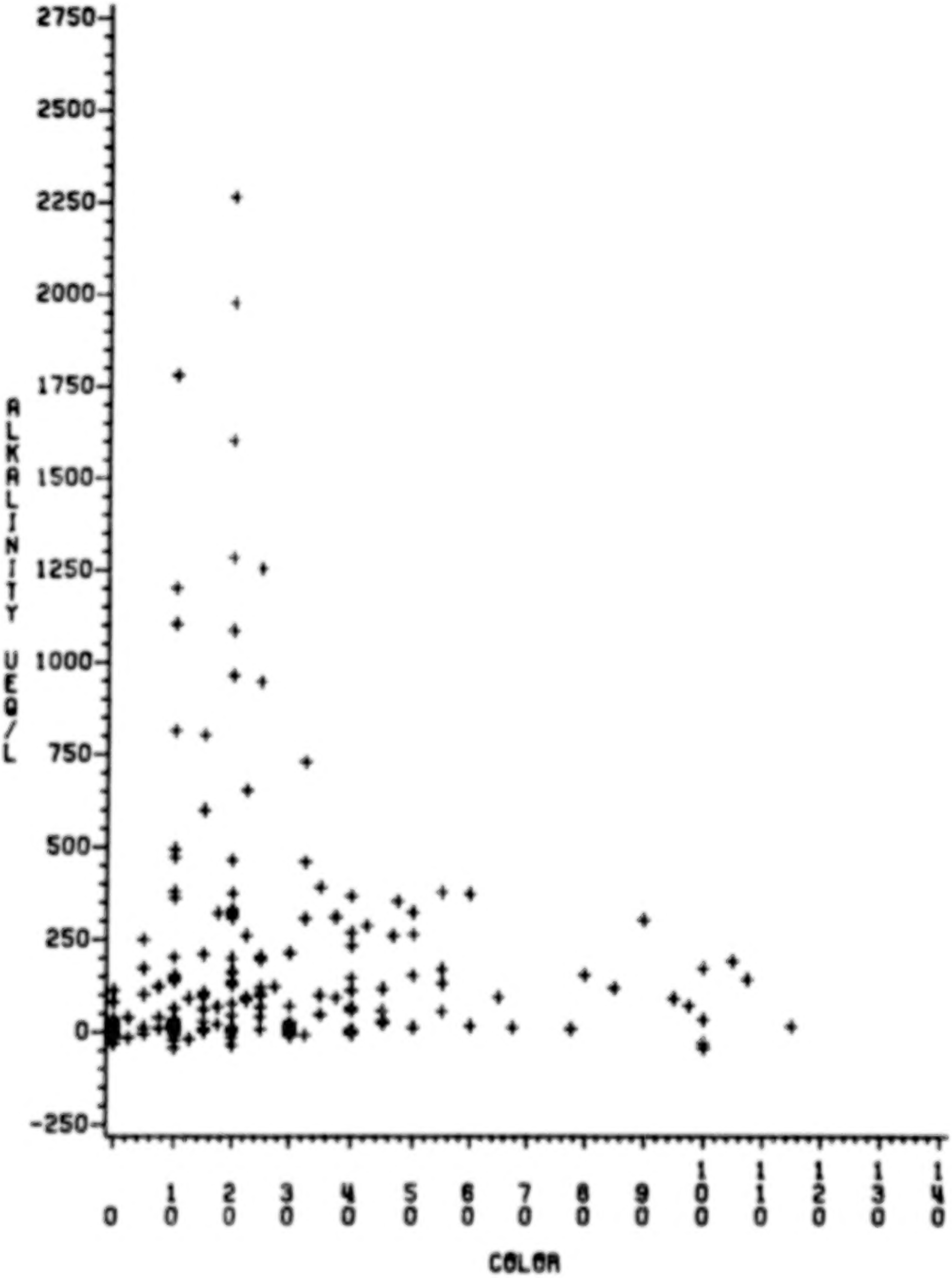

Figure 22. Relationship of alkalinity to apparent color. Data are means of two replicates and means of surface and deep samples if taken.

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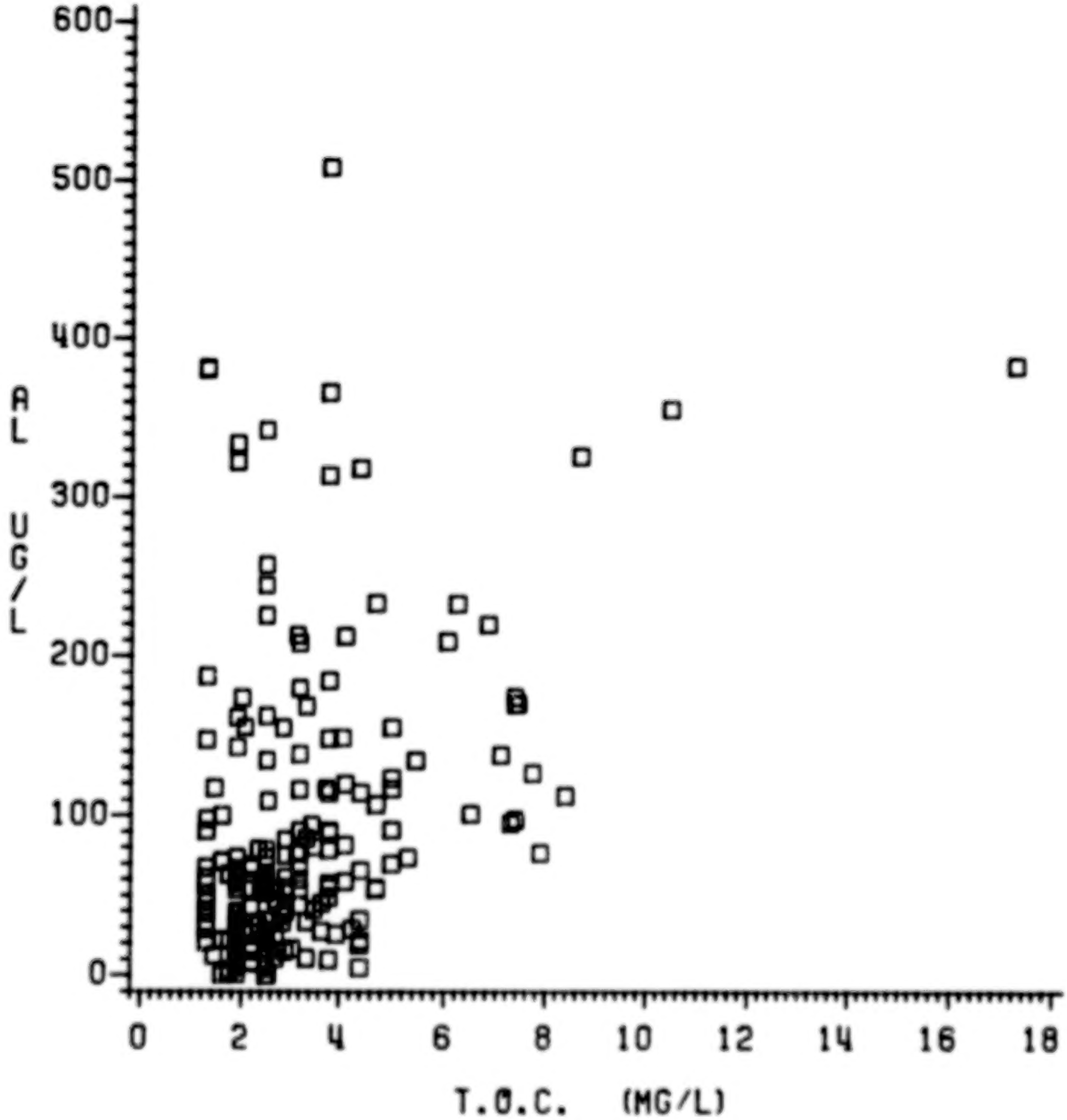

Figure 23. Comparison of aluminum concentration to total organic carbon concentration in 196 New England lakes and streams.

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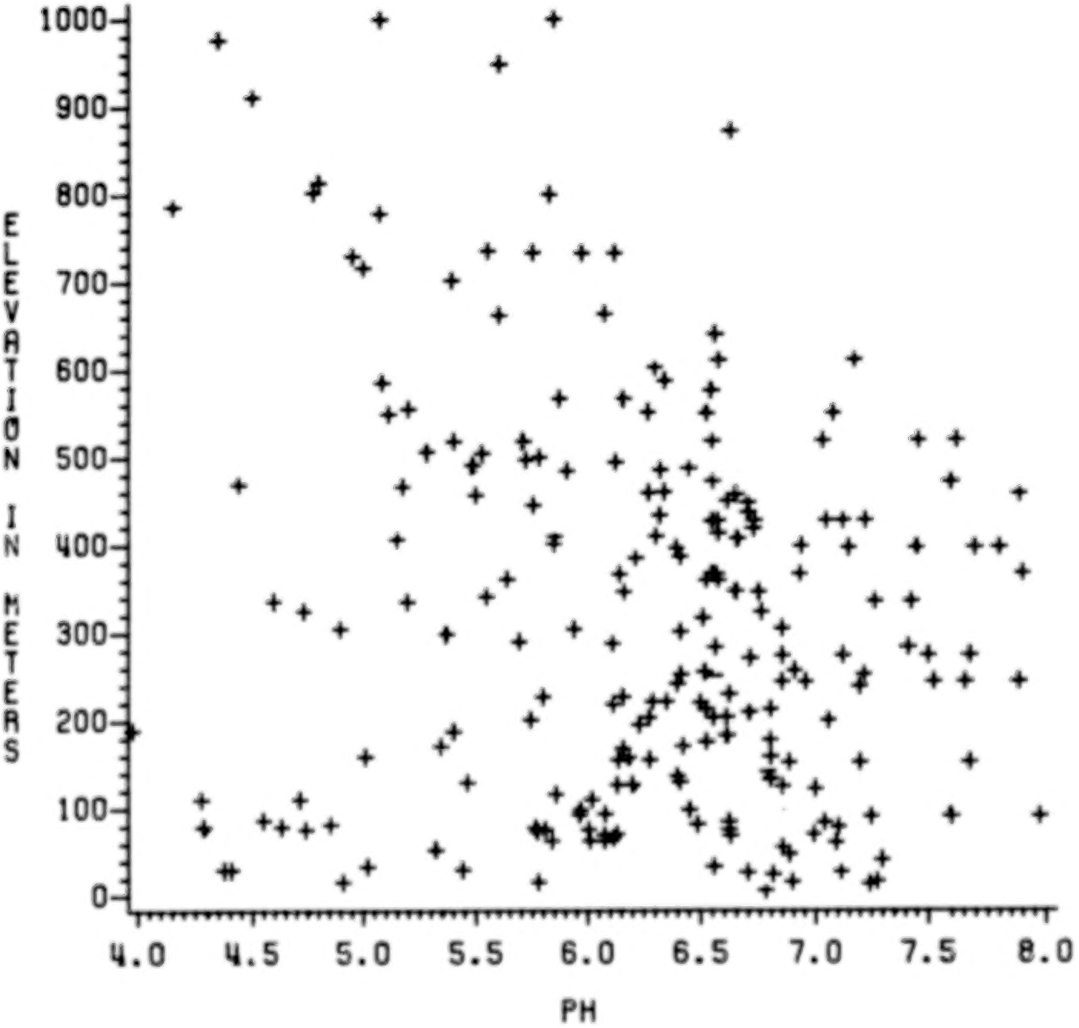

Figure 24. Relationship of elevation of sample site to pH. Elevation was determined from U.S. Geological Survey topographic maps. The pH data are means of two replicates and means of surface and deep samples if taken.

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of pH <5 are distributed throughout the range of 10 to 1,000 m elevation. However, waters with pH of 6.5 or more were seldom found above 600 m. A similar situation exists with alkalinity (Figure 25). Surface waters with negligible alkalinity were found at all elevations from 10 to 1,000 m, but all but two lakes located at 600 m elevation or higher had alkalinity of 100 $\mu eq\ l^{-1}$ or less.

The influence of elevation on surface water chemistry is most likely a complex interrelationship of bedrock geology, soil type and depth, depth of glacial till, and watershed size. Higher elevation areas would be expected to have bedrock that is resistant to chemical weathering, and thin soils and till. Watersheds may be smaller at higher elevation because of the steepness of the terrain. The presence of low pH and low alkalinity waters at low elevation indicates that marine influence does not necessarily result in increased buffering capacity in New England, in contrast to the situation in Norway. Some very acidic lakes are located near the seacoast in Maine, Massachusetts, and Rhode Island. In Norway acidic lakes were rare at elevations less than 200 m, because of the presence of readily weathered sediments deposited during the late Pleistocene marine submergence (Wright and Snekvik 1978). Although the proportion of acidic lakes and streams is greater at higher elevations in New England, there are as many acidic lakes at lower as at higher elevations.

Size

In general, acidic lakes were also small lakes. All but two lakes that had a pH of 5.5 or less were also less than 20 ha surface area (Figure 26). Obviously, not all small lakes were acidic, but lakes larger than 20 ha rarely were. But the larger lakes were low in alkalinity (Figure 27). All but two lakes with area greater than 20 ha also had alkalinity of 400 $\mu eq\ l^{-1}$ or less. Other regional surveys of lake chemistry seem not to have considered lake area as a factor governing chemistry. In general, larger lakes would be expected to have larger, more complex watersheds with a greater variety of bedrock types and thicker soils. Therefore we expected larger lakes to be better buffered and higher in pH (lower in hydrogen ion). The largest lakes we surveyed were relatively low in alkalinity, and therefore buffering capacity, yet tended to be of higher pH than smaller lakes of comparable alkalinity.

There is apparently some factor related to size that caused the larger lakes to have lower concentrations of hydrogen ion than smaller lakes of the same alkalinity. One possible explanation is watershed size. Larger lakes tend to have larger watersheds, which may be capable of neutralizing more hydrogen ion even though they are low in bufering capacity. This could be the result of lower-gradient slopes and thicker soils and till, which would allow more contact time. We tested this hypothesis using lakes in Maine, for which drainage area data were available. We compared $\log_{10}$ drainage area to pH, drainage area to

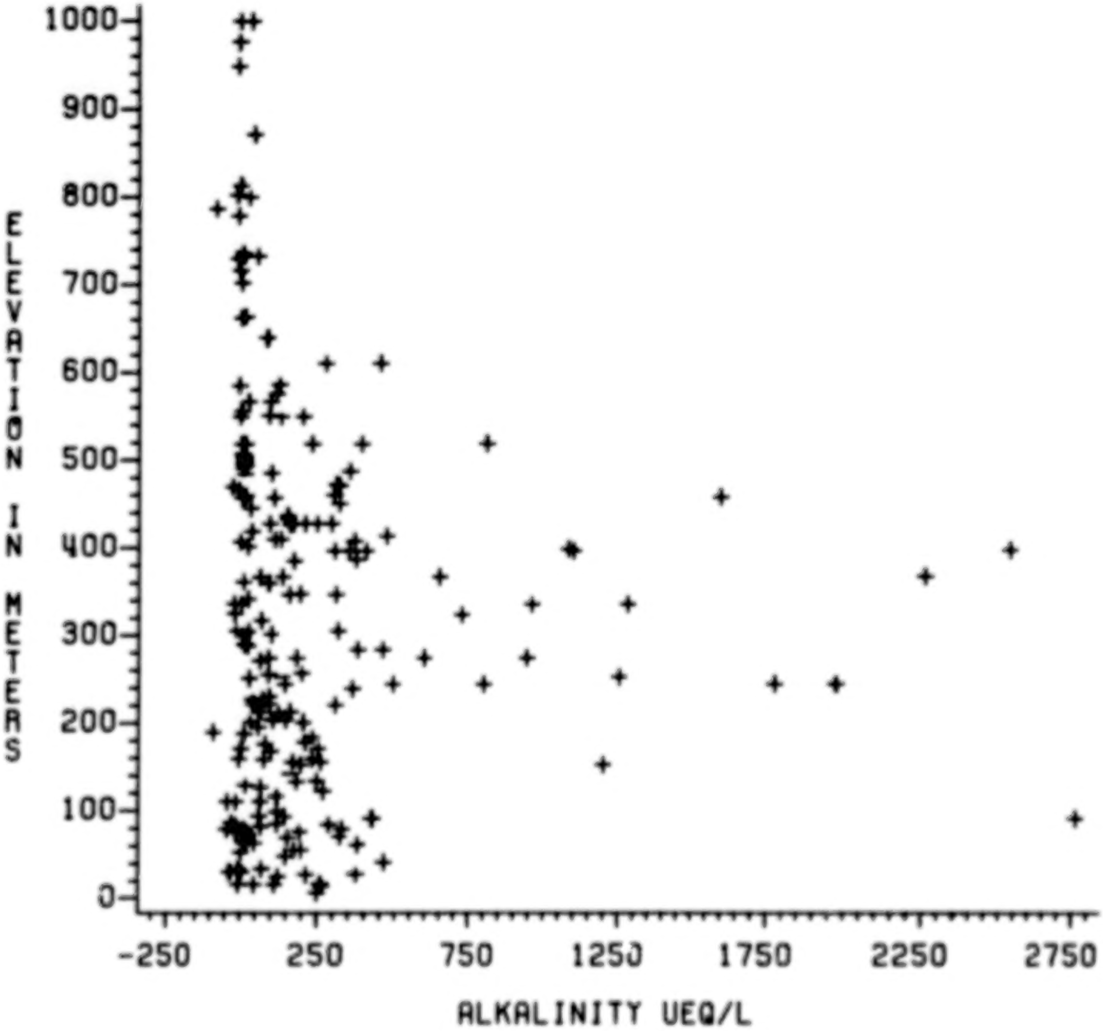

Figure 25. Relationship of sample site elevation to alkalinity. Elevation was obtained from U.S. Geological Survey topographic maps. Alkalinity data are means of two replicates and means of surface and deep samples where taken.

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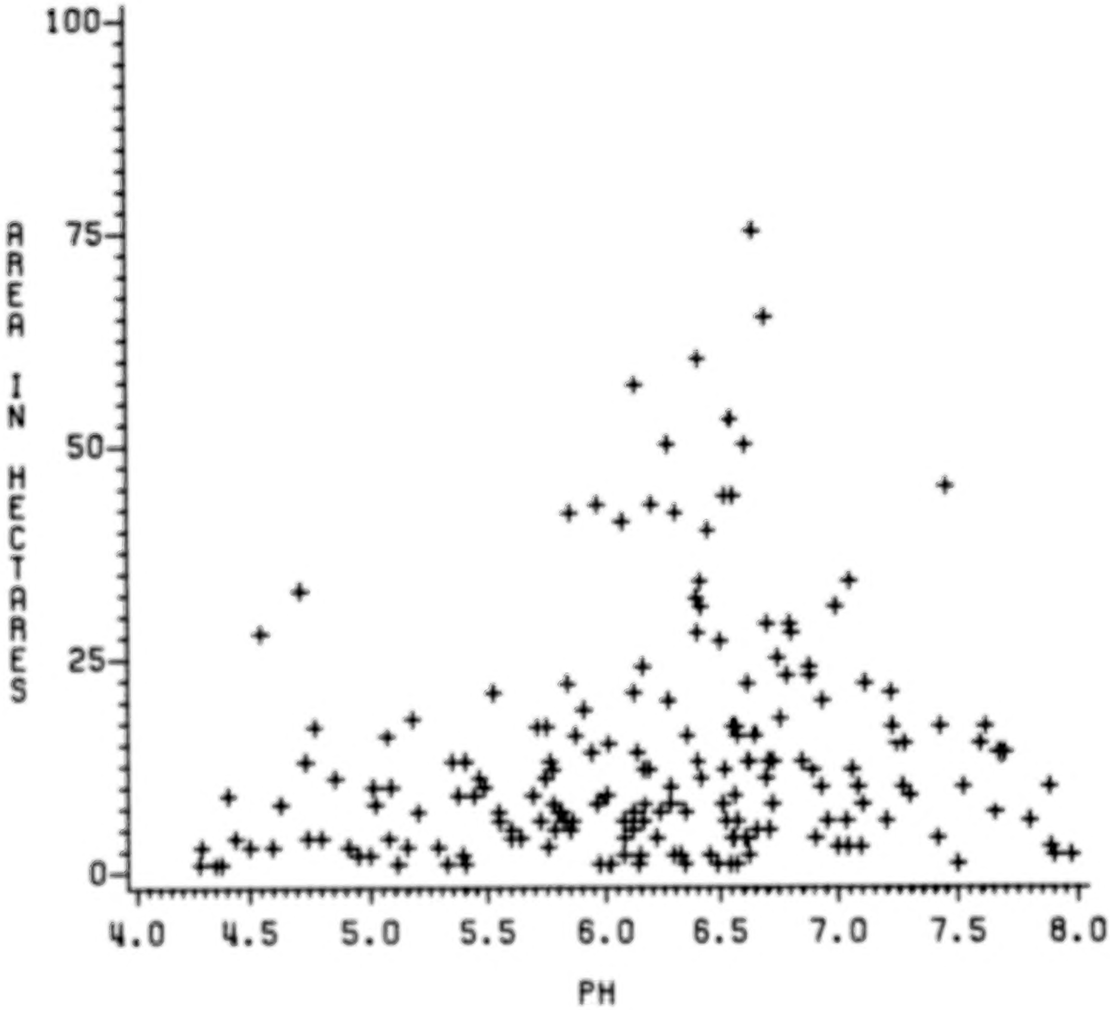

Figure 26. Relationship of lake area to pH. The pH data are means of two replicates and means of surface and deep samples where taken.

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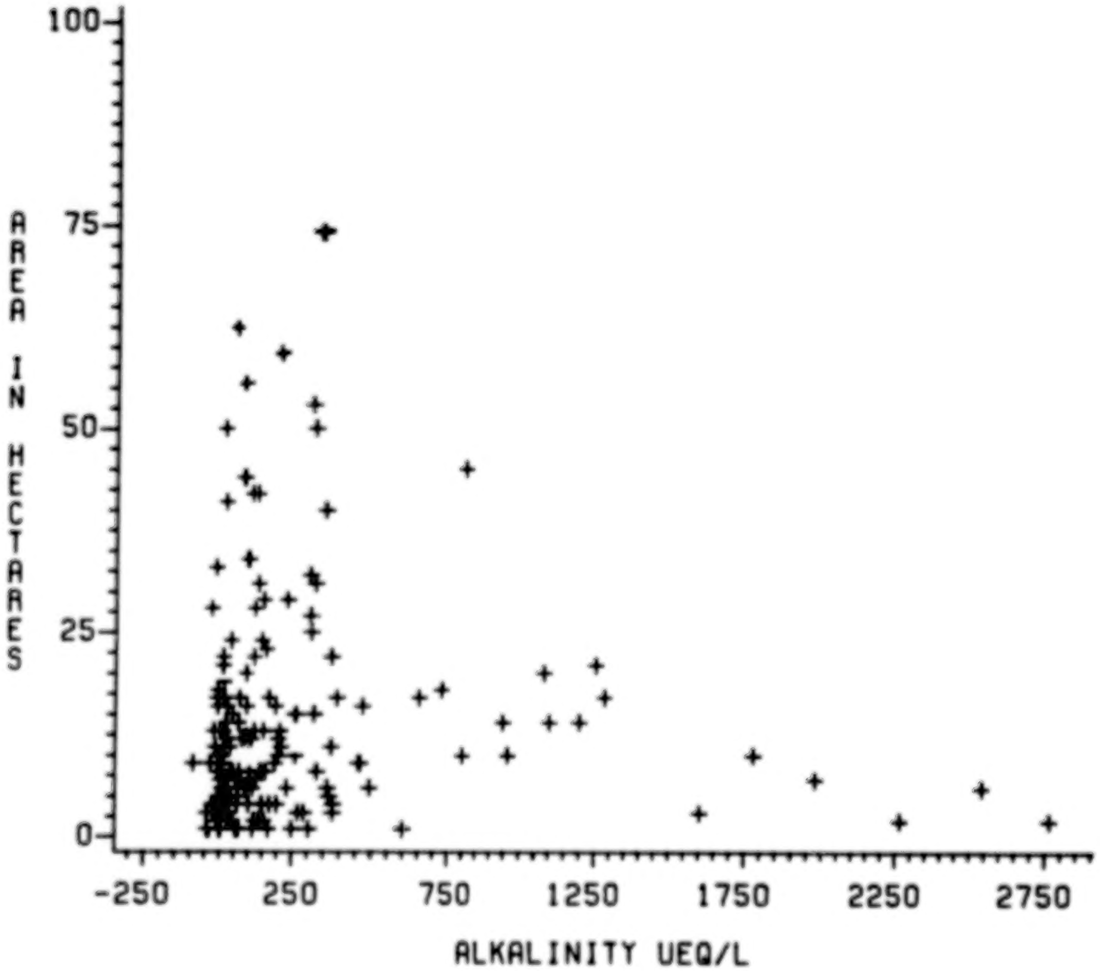

Figure 27. Relationship of lake area to alkalinity. Alkalinity data are means of two replicate and means of surface and deep samples where taken.

alkalinity, and the ratio lake area/drainage area to pH and alkalinity by use of linear regression. The only statistically significant regression was for $\log_{10}$ drainage area and pH ($r^2 = 0.14$, $p < 0.003$; Figure 28). This supports the hypothesis that increased area of the drainage basin can neutralize increased amounts of hydrogen ion independent of alkalinity.

## Drainage Type

Lakes were classed as drainage lakes (with outlet) and seepage lakes (no outlet). The two types of hydrology apparently do not significantly affect lake water chemistry (Table 11). Drainage lakes had a nearly significant tendency to be more highly colored than seepage lakes. In contrast to this, lake hydrology was an important factor in controlling buffering capacity in northern Wisconsin lakes. (Eilers *et al.*, in preparation).

Lakes and streams were chemically similar, differing only in pH, sodium, and potassium (Table 12). The streams were higher in pH, which may reflect the acid neutralizing effect of larger watershed area or the fact that lakes can receive an appreciable amount of precipitation directly on the lake surface, without watershed contact.

## Stream Order

Higher order streams tended to be higher in pH and alkalinity, specific conductance, Calcite Saturation Index, calcium, magnesium, sodium, potassium, and chloride (Table 13). There were no siginifcant differences for aluminum, manganese, sulfate, or color. This pattern is as expected, because higher order streams have larger watersheds and are more likely to include a variety of bedrock geology types.

## Bedrock and Soil Class

Bedrock geology type had a pronounced effect on chemical factors related to acidity and buffering capacity, but little effect on other factors (Table 14). Mean pH, alkalinity, specific conductance, calcium, and magnesium increased consistently along the spectrum from bedrock type 1 (very low buffering capacity) to type 4 (very high buffering capacity), and calcite saturation index consistently decreased.

Waters located in areas where bedrock was class 1 or 2 varied widely in pH (Figure 29) covering nearly the entire range measured. Waters underlain by bedrock class 3 or 4, however, were largely restricted to higher pH. Low alkalinity waters were much more abundant in areas with bedrock class 1 and 2, and high alkalinity waters were more abundant in class 3 and 4 (Figure 30). However, low alkalinity waters were found in all bedrock classes.

The bedrock geology classes devised by Hendrey *et al.* (1980) were intended to reflect buffering capacity inherent in the bedrock. This

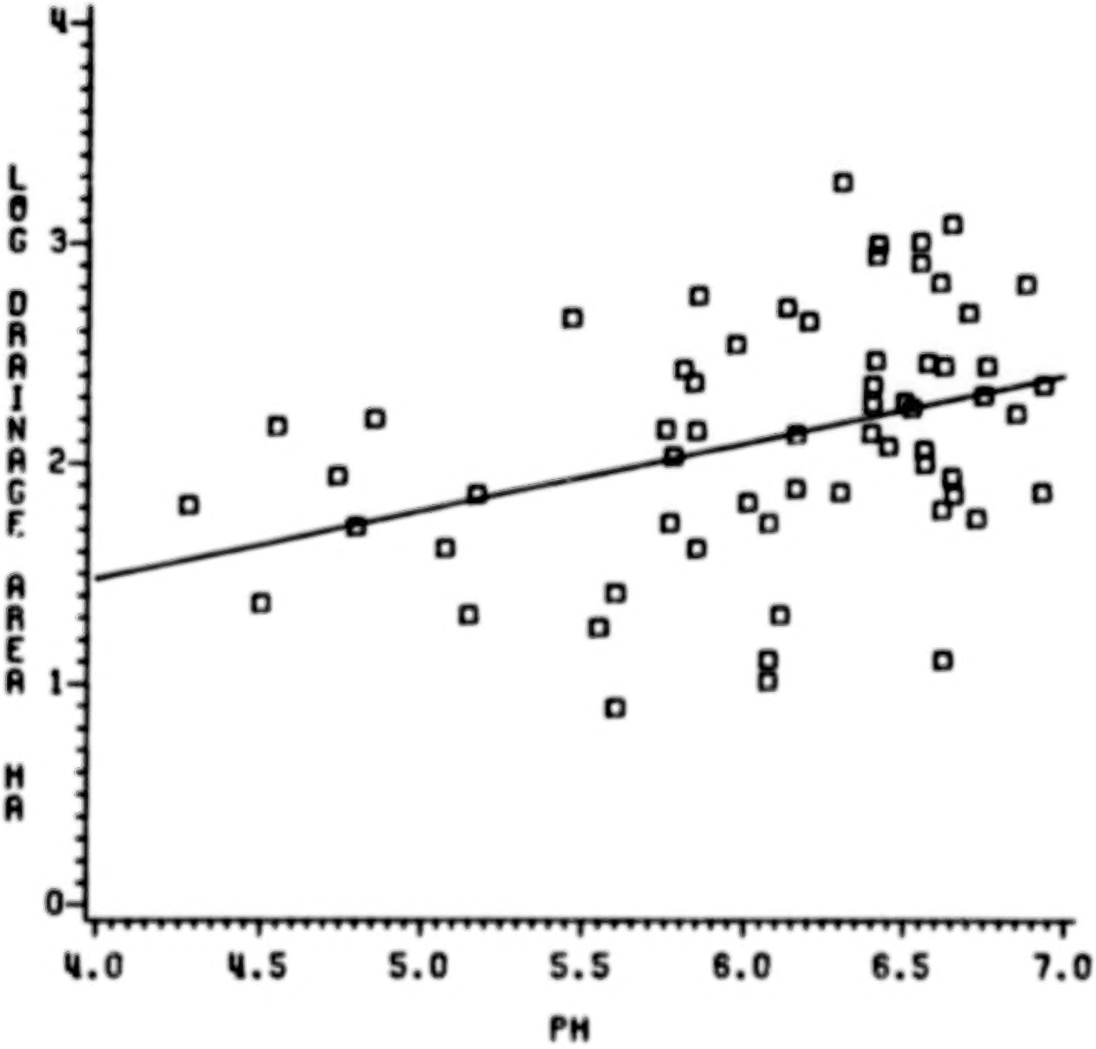

Figure 28. Relationship of $\log_{10}$ drainage area to lake pH. Lake pH values are means of two replicates and means of surface and deep samples where taken. Least squares regression equation:

log drainage area - 0.26 + 0.31 (pH).

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Table 11. Mean Values and Standard Deviations of Chemical Factors for Lakes Classed by Hydrology Type. P is Probability that Means are Drawn From the Same Populations, One Way Analysis of Variance Test

| Factor | Hydrology type | | | | P |
|---|---|---|---|---|---|
| | Drainage | | Seepage | | |
| | $\bar{X}$ | S.D. | $\bar{X}$ | S.D. | |
| PH, units | 6.34 | 0.86 | 6.27 | 0.91 | 0.66 |
| Alkalinity, $\mu eq\ l^{-1}$ | 231 | 411 | 220 | 483 | 0.88 |
| Specific conductance, $\mu S\ cm^{-1}$ | 54 | 47 | 49 | 46 | 0.51 |
| Calcite saturation index, units | 3.67 | 1.72 | 3.52 | 1.67 | 0.62 |
| Calcium, $mg\ l^{-1}$ | 5.4 | 7.4 | 4.5 | 7.4 | 0.45 |
| Magnesium, $mg\ l^{-1}$ | 0.9 | 0.7 | 1.1 | 1.9 | 0.39 |
| Sodium, $mg\ l^{-1}$ | 2.3 | 2.6 | 2.5 | 3.0 | 0.61 |
| Potassium, $mg\ l^{-1}$ | 0.6 | 0.5 | 0.6 | 0.5 | 0.95 |
| Aluminum, $\mu g\ l^{-1}$ | 85 | 111 | 89 | 113 | 0.83 |
| Manganese, $\mu g\ l^{-1}$ | 40 | 46 | 38 | 30 | 0.80 |
| Chloride, $mg\ l^{-1}$ | 3.6 | 5.2 | 3.5 | 4.6 | 0.95 |
| Sulfate, $mg\ l^{-1}$ | 7.4 | 5.7 | 6.4 | 2.2 | 0.15 |
| Color | 30 | 28 | 23 | 19 | 0.06 |

Table 12. Chemical Factor Means and Standard Deviations for Lakes and Streams. P is Probability that Means are Drawn From the Same Populations, One Way Analysis of Variance Test

| | Lake | | Stream | | P |
|---|---|---|---|---|---|
| | $\bar{X}$ | S.D. | $\bar{X}$ | S.D. | |
| PH, units | 6.29 | 0.89 | 6.74 | 0.53 | 0.01* |
| Alkalinity, $\mu$eq $l^{-1}$ | 281 | 534 | 217 | 130 | 0.55 |
| Specific conductance, $\mu$S $cm^{-1}$ | 54 | 53 | 57 | 28 | 0.81 |
| Calcium, mg $l^{-1}$ | 5.4 | 8.4 | 4.0 | 2.0 | 0.40 |
| Magnesium, mg $l^{-1}$ | 1.1 | 1.7 | 1.2 | 0.7 | 0.73 |
| Aluminum, $\mu$g $l^{-1}$ | 84 | 101 | 71 | 82 | 0.55 |
| Manganese, $\mu$g $l^{-1}$ | 39 | 35 | 45 | 45 | 0.44 |
| Sodium, mg $l^{-1}$ | 2.2 | 2.6 | 3.5 | 2.5 | 0.02* |
| Potassium, mg $l^{-1}$ | 0.6 | 0.5 | 1.2 | 0.5 | <0.01* |
| Chloride, mg $l^{-1}$ | 3.2 | 4.6 | 5.2 | 5.1 | 0.06 |
| Sulfate, mg $l^{-1}$ | 6.5 | 2.5 | 6.9 | 2.3 | 0.46 |
| Color, units | 14 | 80 | 12 | 66 | 0.39 |

*Significant for $\alpha = 0.05$

Table 13. Relationship of Stream Order to Water Chemistry Factors. Values Reported are Arithmetic Means of all Available Samples. Means with the Same Superscript Letter are not significantly Different (One Way Analysis of Variance Test with Scheffe's Comparison, $p \leq 0.05$)

| Factor | Stream order | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| PH, units | $6.3^{a}$ | $6.2^{a}$ | $7.2^{a,c}$ | $7.0^{b,c}$ |
| Alkalinity, $\mu eq\ l^{-1}$ | $174^{a}$ | $85^{a,b}$ | $302^{a,c,d}$ | $241^{a,d}$ |
| Specific conductance, $\mu S\ cm^{-1}$ | $43^{a}$ | $35^{a}$ | $54^{a,c}$ | $71^{b,c}$ |
| Calcite saturation index, units | $3.5^{a}$ | $3.8^{a}$ | $2.5^{a,c}$ | $2.6^{b,c}$ |
| Calcium, $mg\ l^{-1}$ | $3.7^{a}$ | $2.4^{a,b}$ | $3.5^{a}$ | $4.5^{a,c}$ |
| Magnesium, $mg\ l^{-1}$ | $1.0^{a}$ | $0.5^{a,b}$ | $1.7^{a,c}$ | $1.3^{a,c}$ |
| Sodium, $mg\ l^{-1}$ | $2.2^{a}$ | $2.4^{a,c}$ | $3.0^{a,c}$ | $4.9^{b}$ |
| Potassium, $mg\ l^{-1}$ | $0.9^{a}$ | $0.7^{a,c}$ | $1.4^{a,d}$ | $1.5^{b,d}$ |
| Aluminum, $\mu g\ l^{-1}$ | $127^{a}$ | $110^{a}$ | $14^{a}$ | $89^{a}$ |
| Manganese, $\mu g\ l^{-1}$ | $54^{a}$ | $53^{a}$ | $13^{a}$ | $39^{a}$ |
| Chloride, $mg\ l^{-1}$ | $2.5^{a}$ | $3.4^{a,c}$ | $4.0^{a,c}$ | $8.1^{b}$ |
| Sulfate, $mg\ l^{-1}$ | $6.0^{a}$ | $5.5^{a}$ | $5.4^{a}$ | $7.6^{a}$ |
| Color, units | $35^{a}$ | $42^{a}$ | $10^{a}$ | $21^{a}$ |

Table 14. Mean Values of Chemical Factors for Surface Waters Classed by Bedrock Geology. Bedrock Classes: 1 = Very Low Buffering Capacity, 2 = Moderately Low Buffering Capacity, 3 = Moderately High Buffering Capacity, 4 = Very High Buffering Capacity (Hendrey *et al*. 1980). Means with the Same Superscript Letter are not Significantly Different (One-Way Analysis of Variance with Scheffe's Comparison $p \leq 0.05$)

| Factor | Bedrock class | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| PH, units | $6.02^{a}$ | $6.25^{a}$ | $6.86^{b}$ | $7.21^{b}$ |
| Alkalinity, $\mu$eq l$^{-1}$ | $8^{a}$ | $172^{a}$ | $575^{b}$ | $1,025^{b}$ |
| Specific conductance, $\mu$S cm$^{-1}$ | $38^{a}$ | $43^{a}$ | $84^{b}$ | $149^{c}$ |
| Calcium, mg l$^{-1}$ | $2.1^{a}$ | $3.9^{a}$ | $11.5^{b}$ | $18.7^{c}$ |
| Magnesium, mg l$^{-1}$ | $0.7^{a}$ | $0.8^{a}$ | $1.5^{b}$ | $4.8^{c}$ |
| Aluminum, $\mu$g l$^{-1}$ | $90^{a}$ | $80^{a}$ | $110^{a}$ | $114^{a}$ |
| Manganese, $\mu$g l$^{-1}$ | $41^{a}$ | $34^{a}$ | $38^{a}$ | $102^{b}$ |
| Sodium, mg l$^{-1}$ | $2.8^{a}$ | $2.0^{a}$ | $3.1^{a}$ | $2.5^{a}$ |
| Potassium, mg l$^{-1}$ | $0.5^{a}$ | $0.6^{a}$ | $0.8^{a}$ | $0.8^{a}$ |
| Chloride, mg l$^{-1}$ | $4.2^{a}$ | $3.0^{a}$ | $3.2^{a}$ | $2.8^{a}$ |
| Sulfate, mg l$^{-1}$ | $5.5^{a}$ | $6.5^{a,b}$ | $7.6^{b}$ | $15.9^{c}$ |
| Color, units | $26^{a}$ | $26^{a}$ | $25^{a}$ | $28^{a}$ |
| Calcite saturation index, units | $4.08^{a}$ | $3.87^{a}$ | $2.03^{b}$ | $1.68^{c}$ |

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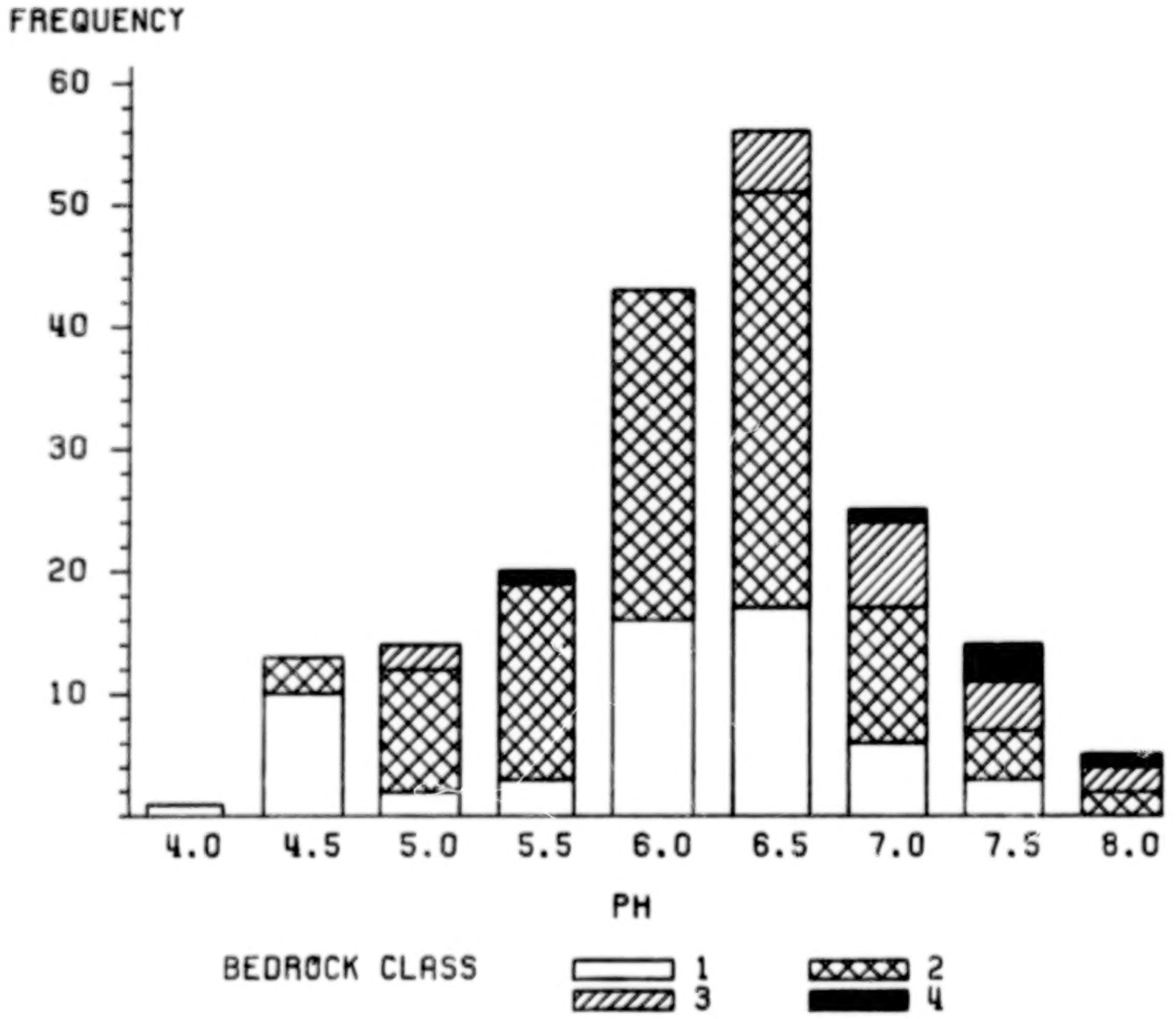

Figure 29. Frequency distribution of surface waters by bedrock geology in pH intervans. Each pH value given is the midpoint of the interval, ± 0.05 unit.

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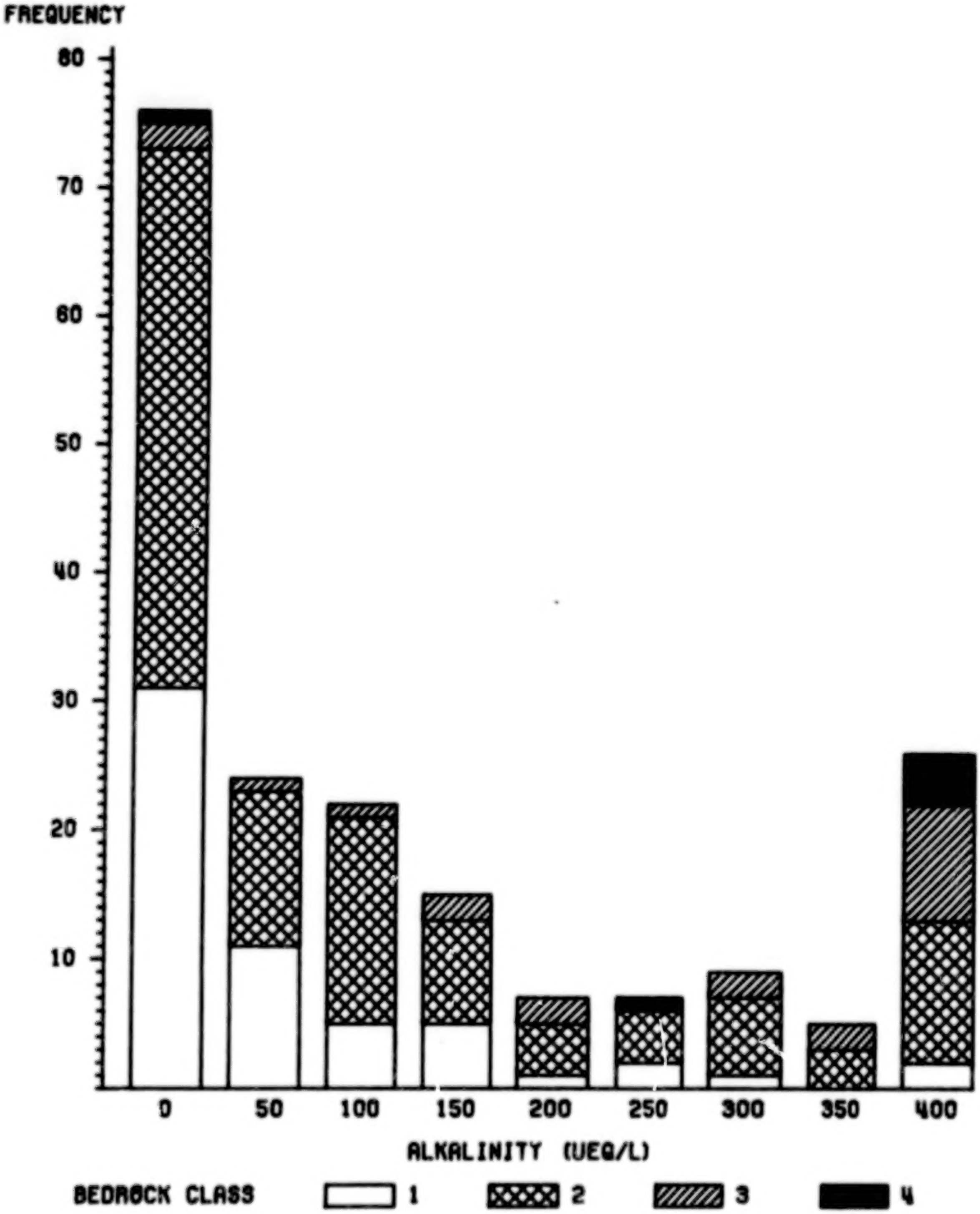

Figure 30. Frequency distribution of surface waters by bedrock geology in alkalinity intervals. Each alkalinity value given is the midpoint of the interval, ± 50 μeq $l^{-1}$.

geological factor does affect surface water chemistry for those chemical factors that are related to acidity and buffering capacity but not other factors, as intended. The relationships are consistent but lack precision because of high variability within a bedrock class. Waters located in bedrock classes 1 and 2 were not significantly different from each other for any chemical factor measured, and classes 3 and 4 were different for only a few factors. Based on the above analysis bedrock types 1 and 2 were pooled and types 3 and 4 were pooled. The ability of these groupings to predict surface water sensitivity to acidification was tested by preparing a contingency table for bedrock geology and alkalinity. Bedrock types 1 and 2 were termed sensitive and types 3 and 4 were termed non-sensitive. Waters with alkalinity of 200 $\mu eq\ l^{-1}$ or less were termed sensitive and those exceeding 200 $\mu eq\ l^{-1}$ were termed non-sensitive. The hypothesis that bedrock class has no effect on alkalinity was tested by use of a contingency table (Table 15). From this table we calculated $\chi^2$, the log-likelihood ratio (G-statistic), and the odds ratio (Bliss 1967, Fleiss 1981). The $\chi^2$ and G statistics were highly significant ($p < 0.001$). The odds ratio indicated that a sensitive lake or stream is nine times more likely to be found in bedrock class 1 or 2 as in class 3 or 4.

There were only three of the five possible types of soil groups (McFee 1980) in New England: $SS_1$, $SS_2$, and NS. The highly sensitive groups (S1, S2) were not present. Soil type was much less important than bedrock type in affecting surface water chemistry (Table 16). Classes SS1 and SS2 were not significantly different for any factor measured. SS1 and SS2 were both significantly different from NS for alkalinity, calcium, sodium, and chloride. Class SS2 alone was different from NS for pH and sulfate.

Soil classes in our sample were distributed nearly normally with respect to pH (Figure 31), with intermediate pHs being most common in all soil classes and waters of all pHs being found in nearly every soil type. The relationship of soil classes to alkalinity (Figure 32) is highly skewed with an abundance low alkalinity waters. But the proportion of soil classes within each alkalinity interval is nearly equal, and waters of all alkalinities are found in each soil class.

The predictive ability of soil class for alkalinity, calculated in the same manner as for bedrock geology, is shown in Table 17. Soil classes SS1 and SS2 were combined as sensitive for this comparison. The $^2$ and G statistics were highly significant ( $\chi^2$ $p < 0.001$, G $p < 0.005$). The odds ratio indicates that sensitive lakes and streams are three times more likely to be found in areas with sensitive soil class than in areas with non-sensitive soils. Thus soil class is not as good a predictor of alkalinity as is bedrock class. Kaplan *et al.* (1981), working with different bedrock and soil classes, concluded that there was no direct influence of bedrock on surface water chemistry but there was for soil type, and bedrock indirectly influenced water chemistry through soils. However, the data set used in Kaplan's study consisted largely of

Table 15. Contingency Table Tests of the Predictive Ability of Bedrock Geology for Surface Water Alkalinity. Table Entries are Numbers of Lakes Sampled.

| Bedrock class | Alkalinity class<br>Sensitive<br>$\leq 200\ \mu eq\ l^{-1}$ | <br>Non-sensitive<br>$>200\ \mu eq\ l^{-1}$ | Total |
|---|---|---|---|
| Sensitive (Class 1 & 2) | 135 | 29 | 164 |
| Non-sensitive (Class 3 & 4) | 9 | 18 | 27 |
| Total | 144 | 47 | 191 |

Test statistics

$\chi^2$ = 29.98 ($p < .001$)

G = 25.75 ($p < .001$)

$\omega$ = 9.31 ($p < .01$)

$S.E._{\omega}$ = 4.26

Table 16. Mean Values for Chemical Factors Classed by Soil Cation Exchange Capacity. Soil Class: $SS_1$ = Slightly Sensitive Soils Dominate Area, $SS_2$ = Slightly Sensitive Soils are Significant but Less than 50% of the Area, NS = Mostly Non-Sensitive Soils (McFee 1980). Means with the Same Superscript Letter are not Significantly Different (One-Way Analysis of Variance with Scheffe's Comparison $p \leq 0.05$)

| Factor | Soil type | | |
|---|---|---|---|
| | $SS_1$ | $SS_2$ | NS |
| PH, units | $6.22^{a,b}$ | $6.06^{a}$ | $6.46^{b}$ |
| Alkalinity, $\mu$eq l$^{-1}$ | 157a | $83^{a}$ | $331^{b}$ |
| Specific conductance, $\mu$S cm$^{-1}$ | $49^{a}$ | $44^{a}$ | $55^{a}$ |
| Calcium, mg l$^{-1}$ | $3.2^{a}$ | $2.5^{a}$ | $7.0^{b}$ |
| Magnesium, mg l$^{-1}$ | $1.1^{a}$ | $0.8^{a}$ | $1.1^{a}$ |
| Aluminum, $\mu$g l$^{-1}$ | $83^{a}$ | $77^{a}$ | $95^{a}$ |
| Manganese, $\mu$g l$^{-1}$ | $35^{a}$ | $40^{a}$ | $40^{a}$ |
| Sodium, mg l$^{-1}$ | $3.3^{a}$ | $3.1^{a}$ | $1.7^{b}$ |
| Potassium, mg l$^{-1}$ | $0.7^{a}$ | $0.6^{a}$ | $0.5^{a}$ |
| Chloride, mg l$^{-1}$ | $5.2^{a}$ | $5.6^{a}$ | $1.7^{b}$ |
| Sulfate, mg l$^{-1}$ | $6.1^{a,b}$ | $5.8^{a}$ | $7.5^{b}$ |
| Color, units | $27^{a}$ | $26^{a}$ | $25^{a}$ |

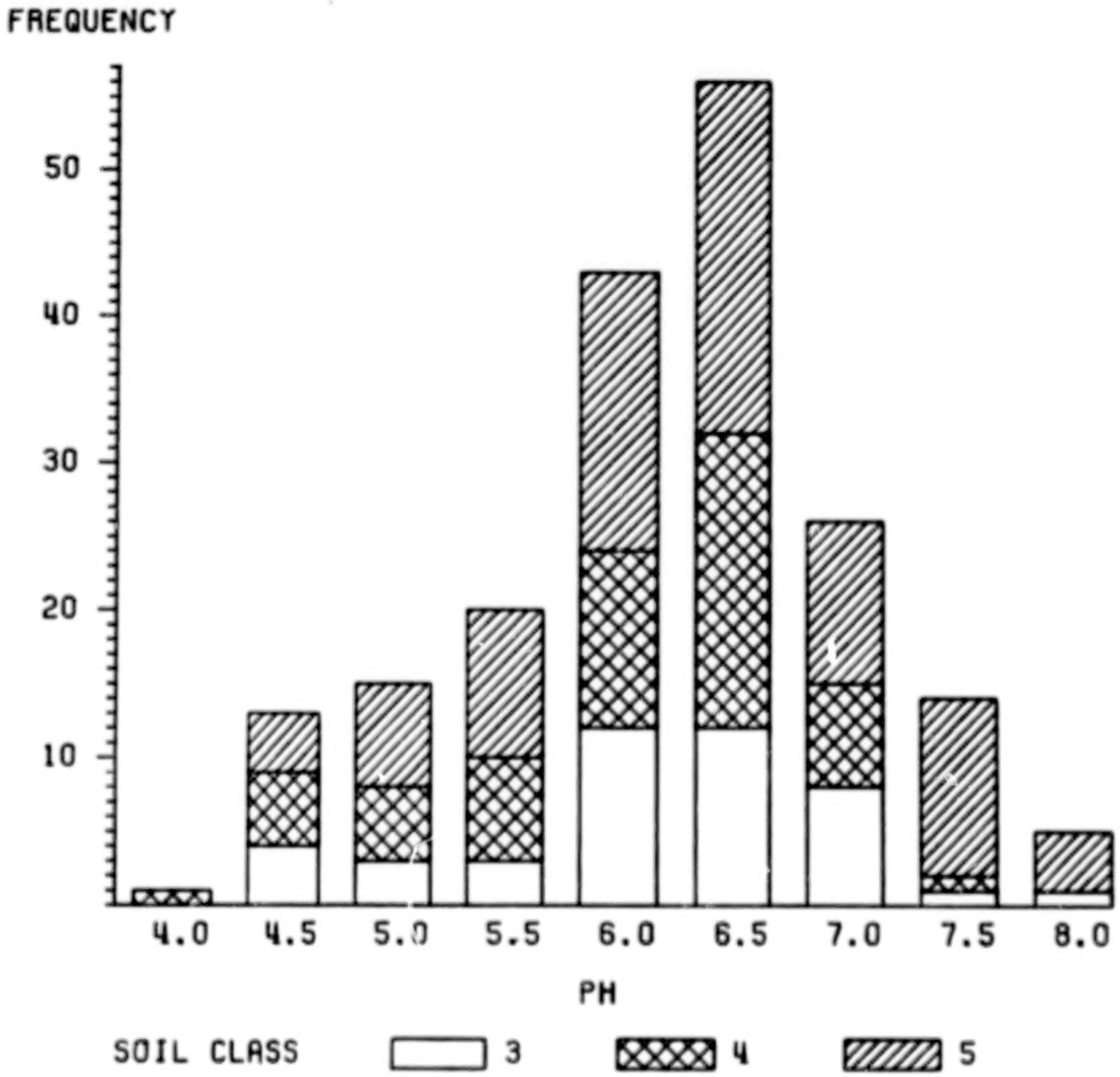

Figure 31. Frequency distribution of surface waters by soil class in pH intervals. Each pH value given is the midpoint of the interval, ± 0.5 unit. Class 3 = $SS_1$, 4 = $SS_2$, 5 = NS.

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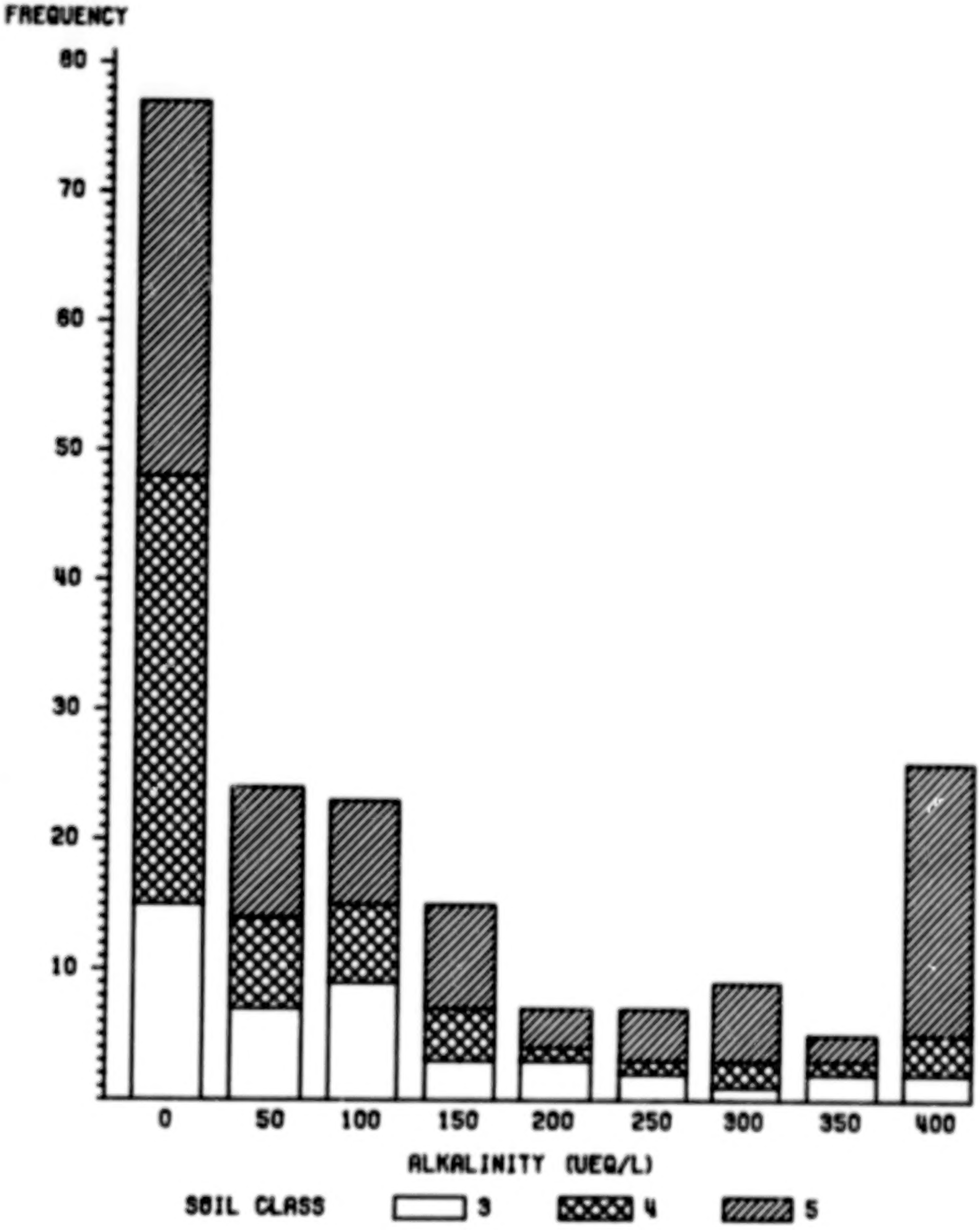

Figure 32. Frequency distribution of waters by soil class in alkalinity intervals. Each alkalinity value given is the midpoint of the interval, ± 50 μeq $l^{-1}$. Class 3 = $SS_1$, 4 = $SS_2$, 5 = NS.

Table 17. Contingency Table Tests of the Predictive Ability of Soil Cation Exchange Capacity for Surface Water Alkalinity. Table Entries are Numbers of Lakes Sampled.

| Soil class | Alkalinity class<br>Sensitive<br>$\leq 200\ \mu eq\ l^{-1}$ | <br>Non-sensitive<br>$>200\ \mu eq\ l^{-1}$ | Total |
|---|---|---|---|
| Sensitive ($SS_1 + SS_2$) | 88 | 14 | 102 |
| Non-sensitive (NS) | 58 | 33 | 91 |
| Total | 146 | 47 | 193 |

Test statistics

$\chi^2 = 13.26$ ($p < .001$)

$G = 8.84$ ($p < .01$)

$\omega = 3.58$ ($p < .05$)

$S.E._{\omega} = 1.29$

lowland sites, where soils would be thicker and more likely to influence water chemistry. In headwater areas soils are likely to be thin and may be absent in large areas, resulting in a greater influence of bedrock on water chemistry. There may also be an interaction between bedrock class and soil class, with sensitive soils being associated with sensitive bedrock. Also, Kaplan et al. (1981) classified bedrock by formation (igneous, metamorphic, etc.) rather than by chemical content. Thus, marble, for example, would be classed as metamorphic and relatively low in buffering capacity.

### Human Disturbance

Human disturbance had an important effect on many water chemistry factors (Table 18). Generally, increasing human disturbance results in increased pH, alkalinity, calcium, magnesium, Calcite Saturation Index, and specific conductance. There was no effect on aluminum, manganese, or color, and minimal effect on sodium and potassium. Chloride, often used as an index of human disturbance, did not increase consistently with disturbance code but mean chloride values were higher in codes 3 and 4 than in codes 1 and 2.

Human activities such as logging, road and building construction, and agriculture disturb natural vegetation and expose soil to increased leaching of chemical constituents. Runoff may also be increased. Disposal of human wastes further adds ions to the receiving waters. This may explain the increase in chemical factors, especially those associated with the buffering complex, with increasing human disturbance. Alternatively, this relationship may result from an interaction between human disturbance and bedrock geology. The waters surveyed in bedrock classes 1 and 2 tended to be low in disturbance whereas those in classes 3 and 4 tended to be high (Table 19). This may reflect the tendency for human activity to be concentrated in areas where soil fertility is high and topography is gentle, which are generally associated with bedrock types high in carbonate minerals.

The role of disturbance in the relationship among chemical factors was evaluated by performing statistical analyses on the entire data set and on waters with disturbance code 1 or 2 only. As there were no major discrepancies that could be attributed to disturbance alone, we used all sample sites in the analyses reported here.

## HISTORICAL COMPARISONS

### pH

Of the 95 locations with usable historical pH data, 34 (36%) either were the same or higher in the recent analysis and 61 (64%) were lower (Figure 33). If there were only random variation, it would be expected that the same proportion of locations would increase as decrease. The recent pH values are significantly lower than historical values (paired t test, $t = 4.17$, $p = <0.0001$).

Table 18. Mean Values for Chemical Factors Classed by Disturbance Code. Disturbance Codes: 1 = No Disturbance, 2 = Slight Disturbance 3 = Moderate Disturbance, 4 = Severe Disturbance. See Text for Description of Disturbance Assessment and Assignment of Classes. Means with the Same Superscript Letters are not Significantly Different (One-Way Analysis of Variance with Scheffe's Comparison, $p \leq 0.05$)

| Factor | Disturbance class | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| PH, units | $6.10^{a}$ | $6.20^{a}$ | $6.88^{b}$ | $7.11^{b}$ |
| Alkalinity, $\mu$eq l$^{-1}$ | $138^{a}$ | $179^{a}$ | $412^{b}$ | $1{,}043^{b}$ |
| Specific conductance, $\mu$S cm$^{-1}$ | $33^{a}$ | $49^{b}$ | $81^{c}$ | $131^{d}$ |
| Calcium, mg l$^{-1}$ | $3.2^{a}$ | $4.5^{a}$ | $7.7^{b}$ | $14.6^{c}$ |
| Magnesium, mg l$^{-1}$ | $0.6^{a}$ | $0.9^{a,b}$ | $1.5^{b}$ | $5.0^{c}$ |
| Aluminum, $\mu$g l$^{-1}$ | $82^{a}$ | $90^{a}$ | $79^{a}$ | $164^{a}$ |
| Manganese, $\mu$g l$^{-1}$ | $32^{a}$ | $41^{a}$ | $46^{a}$ | $52^{a}$ |
| Sodium, mg l$^{-1}$ | $1.3^{a}$ | $2.6^{b}$ | $4.5^{c}$ | $2.9^{a,b,c}$ |
| Potassium, mg l$^{-1}$ | $0.4^{a}$ | $0.5^{a,c}$ | $1.0^{b}$ | $1.0^{b,c}$ |
| Chloride, mg l$^{-1}$ | $1.9^{a}$ | $3.6^{a}$ | $6.0^{b}$ | $5.0^{a,b}$ |
| Sulfate, mg l$^{-1}$ | $5.7^{a}$ | $7.3^{b,c}$ | $6.9^{a,c}$ | $8.8^{a,c}$ |
| Color, units | $23^{a}$ | $26^{a}$ | $31^{a}$ | $16^{a}$ |
| Calcite saturation index, units | $4.0^{a}$ | $3.7^{a}$ | $2.7^{b}$ | $2.1^{b}$ |

Table 19. Number of Surface Waters Sampled in Each Bedrock Class and Disturbance Code. See Text for Explanation of Bedrock and Disturbance Code

| Disturbance Code | Bedrock class 1 | Bedrock class 2 | Bedrock class 3 | Bedrock class 4 |
|---|---|---|---|---|
| 1 | 32 | 71 | 10 | 0 |
| 2 | 47 | 98 | 16 | 8 |
| 3 | 12 | 27 | 12 | 2 |
| 4 | 2 | 0 | 4 | 2 |

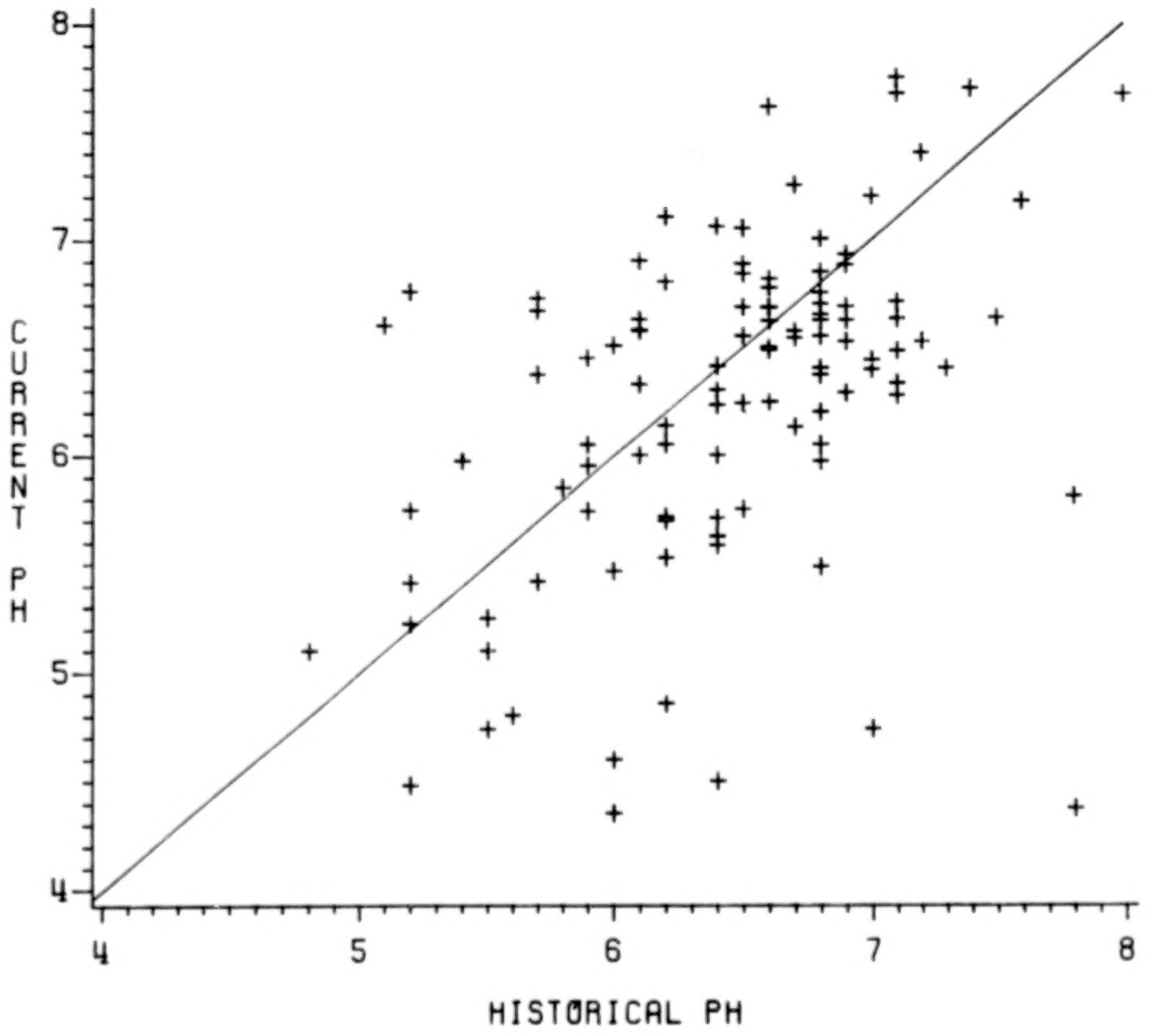

Figure 33. Current versus historical pH for 95 New England lakes. Solid line indicates equivalent pH.

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If the comparison is restricted to those waters that are sensitive to acidification, the proportion that have declined in pH is increased. For waters that presently have alkalinity of 100 μeq $l^{-1}$ or less, 13 of 53 locations (25%) either did not change or increased and 40 of 53 (75%) decreased in pH (Figure 34). This difference is also significant (paired t test, t = 4.38, $p = < 0.0001$). A similar comparison for waters located in bedrock classes 1 or 2 only (the lowest in buffering capacity) gave comparable results (Figure 35).

The mean pH of stations for which historical data were located was 5.37 (calculated from hydrogen ion) versus 6.07 historically. Or, stated another way, mean hydrogen ion increased from 0.8 μeq $l^{-1}$ historically to 4.3 μeq $l^{-1}$ recently, a five-fold increase. The historical data were determined as early as 1937 and as recently as 1978. Data more recent than 1978 were located but not used. There was no obvious trend of change in pH with elapsed time between measurements. However, the historical data set is rather small and includes lakes with a wide range in buffering capacity. Lakes with high buffering capacity would not be expected to change significantly in pH. If only low buffering capacity lakes are considered (alkalinity <100 μeq $l^{-1}$) the data set becomes too small to be meaningful.

The historical pH data comparisons, although not numerous, nevertheless indicate a substantial increase in hydrogen ion content of the lakes that are low in buffering capacity. The historical pH data were largely determined colorimetrically. Only one historical measurement was located that was determined electrometrically. Colorimetric pH indicators may give erroneous results, especially in water with low buffering capacity (Boyd 1976, 1977, 1980; Pfeiffer and Festa 1980; Wright 1977). However, Schofield (1982) showed that the error was not large in Adirondack Mountain lakes, being 0.2 unit or less. We have done extensive testing of the colorimetric indicator methods commonly used in New England and concluded that the limit of accuracy of the method was ±0.2 unit, and the error was unbiased (Haines et al., in press). Norton et al. (1981) compared the two methods for a set of New England lakes and concluded that the two methods were equivalent within 0.1 unit. Almer et al. (1974) measured pH in a number of lakes using both methods and found that the results were comparable, seldom differing by more than 0.2 unit. Lewis (1982) compared electrometric pH measurements with those made with the same type of indicators used 40 years previously and found "good agreement".

Many other comparisons of historical and recent pH data have been made. A number of the most significant ones were reviewed by Haines (1981). Most comparisons that were made in areas where precipitation is acidic (pH < 4.6 annual weighted mean) and where acid neutralizing capacity of bedrock is low have demonstrated similar declines in pH. Many studies in Scandinavia, reviewed by Wright and Gjessing (1976), reported that lakes declined from pH 6-7 during the period 1940-1950 to pH 5-6 in the early 1970's. Wright (1977) compared historical and

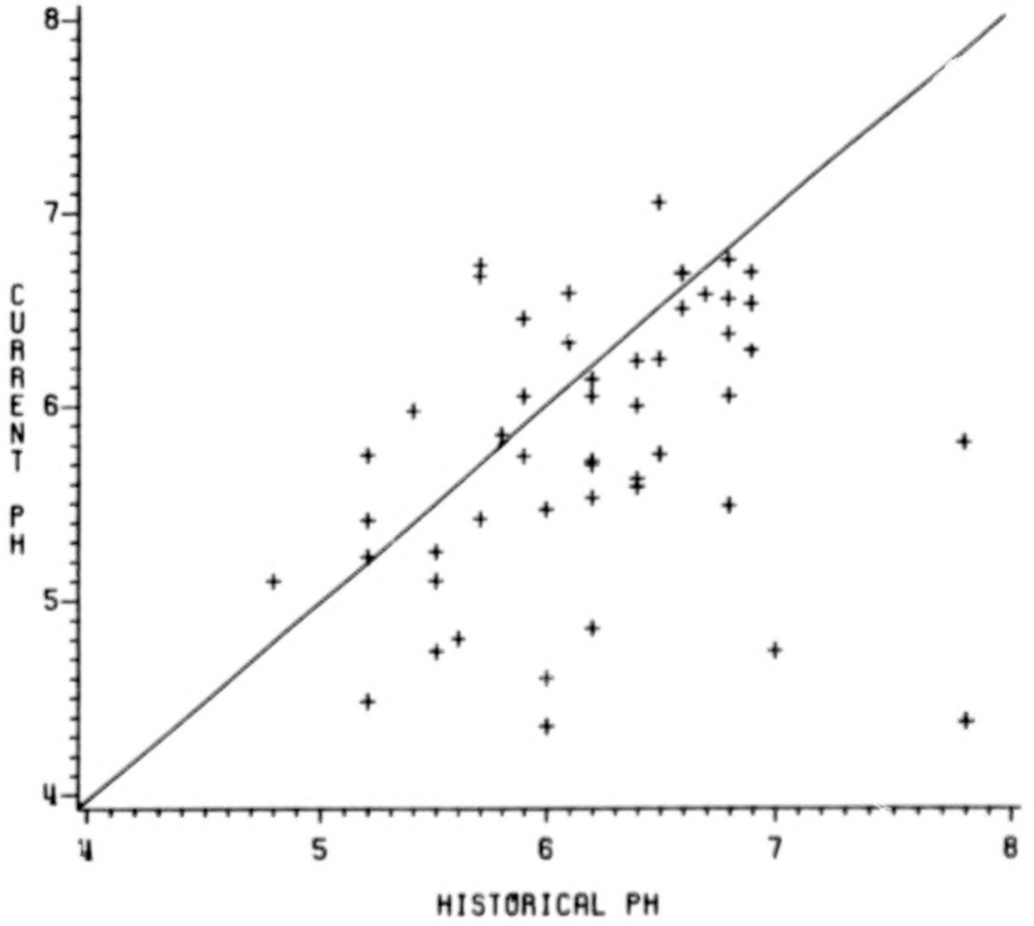

Figure 34. Current versus historical pH for 53 New England lakes with alkalinity of 100 μeq $l^{-1}$ or less. Solid line indicates equivalent pH.

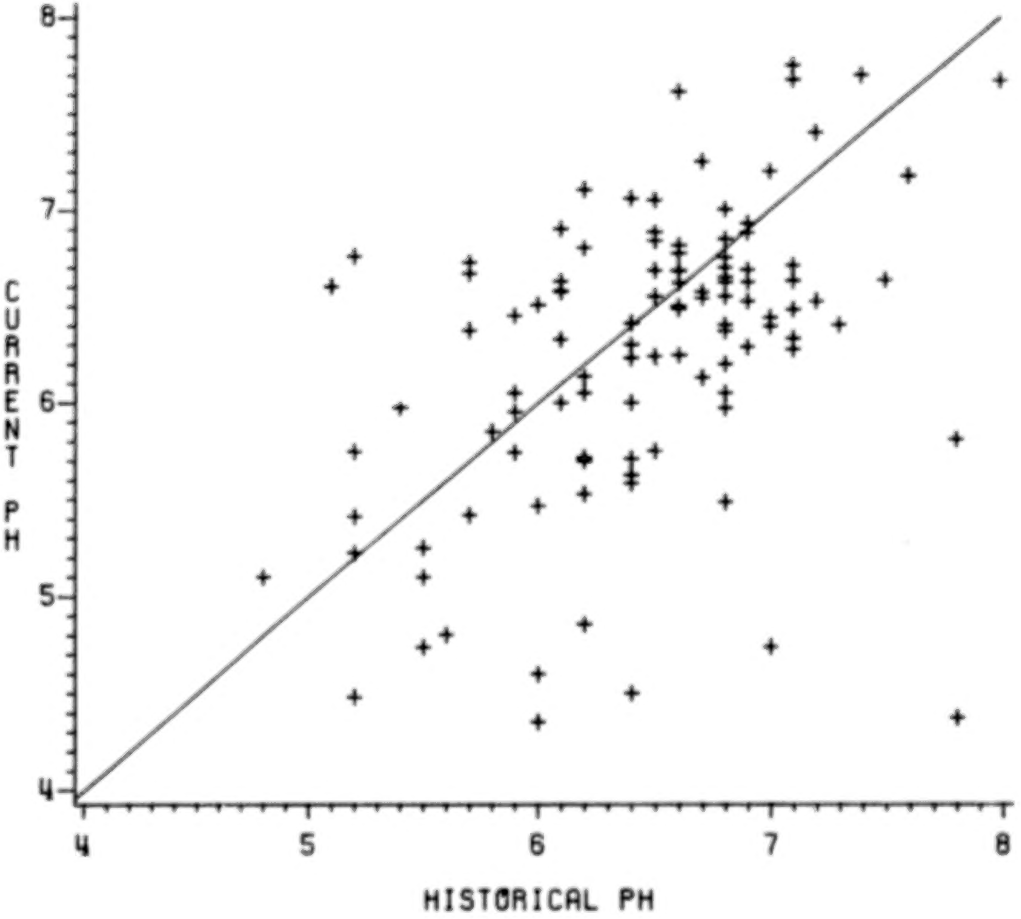

Figure 35. Current versus historical pH for 85 New England lakes located in bedrock class 1 or 2. Solid line indicates equivalent pH.

recent pH data for 128 lakes in southern Norway and found that 63% had become more acidic. Recently, Morling (1981) reported annual pH measurements from 1960-1966 to 1979 for 10 Swedish lakes, with similar results.

McColl (1981) found that the hydrogen ion activity of two reservoirs in the Sierra Nevada mountains of California increased about 0.06 $\mu eq\ l^{-1}$ during the period 1954 to 1979. The mean monthly variation in hydrogen ion was correlated with mean monthly variation in air pollution in the San Francisco Bay Area. Lewis (1982) resurveyed 104 lakes in Colorado that had been surveyed previously. He found that pH declined from a mean value of 7.09 during 1938-1960 to 6.87 recently. Hendrey et al. (1980) resurveyed 42 New Hampshire streams for which historical pH data were available and found that pH had declined in 37 (88%). In a previous survey of Maine lakes, Davis et al. (1978) reported that the pH declined from 6.18 in 1937-1943 to 6.09 in 1969-1974. This small decline most likely results from the fact that the lakes surveyed were large, lowland lakes that were not highly vulnerable to acidification. Recently Norton et al. (1981) reported historical versus recent pH comparisons for 69 lakes in Maine, New Hampshire, and Vermont and found that 51 (74%) had decreased pH. This finding agrees well with our results, and there is some overlap in the data sets.

Alkalinity

Historical alkalinity data were less common than pH. Only 56 lakes had such data. The historical alkalinity data were all obtained by fixed endpoint titrations to pH 4.5 (methyl orange endpoint). This method overestimates true alkalinity because the actual endpoint is not fixed but increased with decreasing alkalinity. We measured both fixed endpoint and inflection point alkalinity for our samples. A comparison of these two values (Figure 36) shows that they are highly linearly correlated (Inflection Point = -32 + 1.00 fixed endpoint; $r^2 = 0.999$). Therefore fixed endpoint alkalinity data can be simply corrected for the overestimation by subtracting 32 $\mu eq\ l^{-1}$, which was done for all historical data. Conversely, we could have compared our fixed endpoint alkalinity values to unadjusted historical values. The results are the same in either case, but presentation of fixed endpoint alkalinity values indicates erroneously high alkalinity levels.

A comparison of adjusted historical to recent alkalinity results (Figure 37) shows that 17 of 56 results (30%) increased or did not change and 39 (70%) decreased. Historical alkalinity data averaged 166 $\mu eq\ l^{-1}$ and recent data averaged 68 $\mu eq\ l^{-1}$, a 60% decrease. This decrease was significant (paired t test, $t = 4.03$, $p = 0.002$). Generally, waters with the highest historical alkalinity exhibited the largest declines. This may be because these waters had alkalinity that could be lost whereas waters that were low in alkalinity historically had little to lose. The highest historical alkalinity value located was 600 $\mu eq\ l^{-1}$, which is not very high on a world-wide basis. As for pH, there

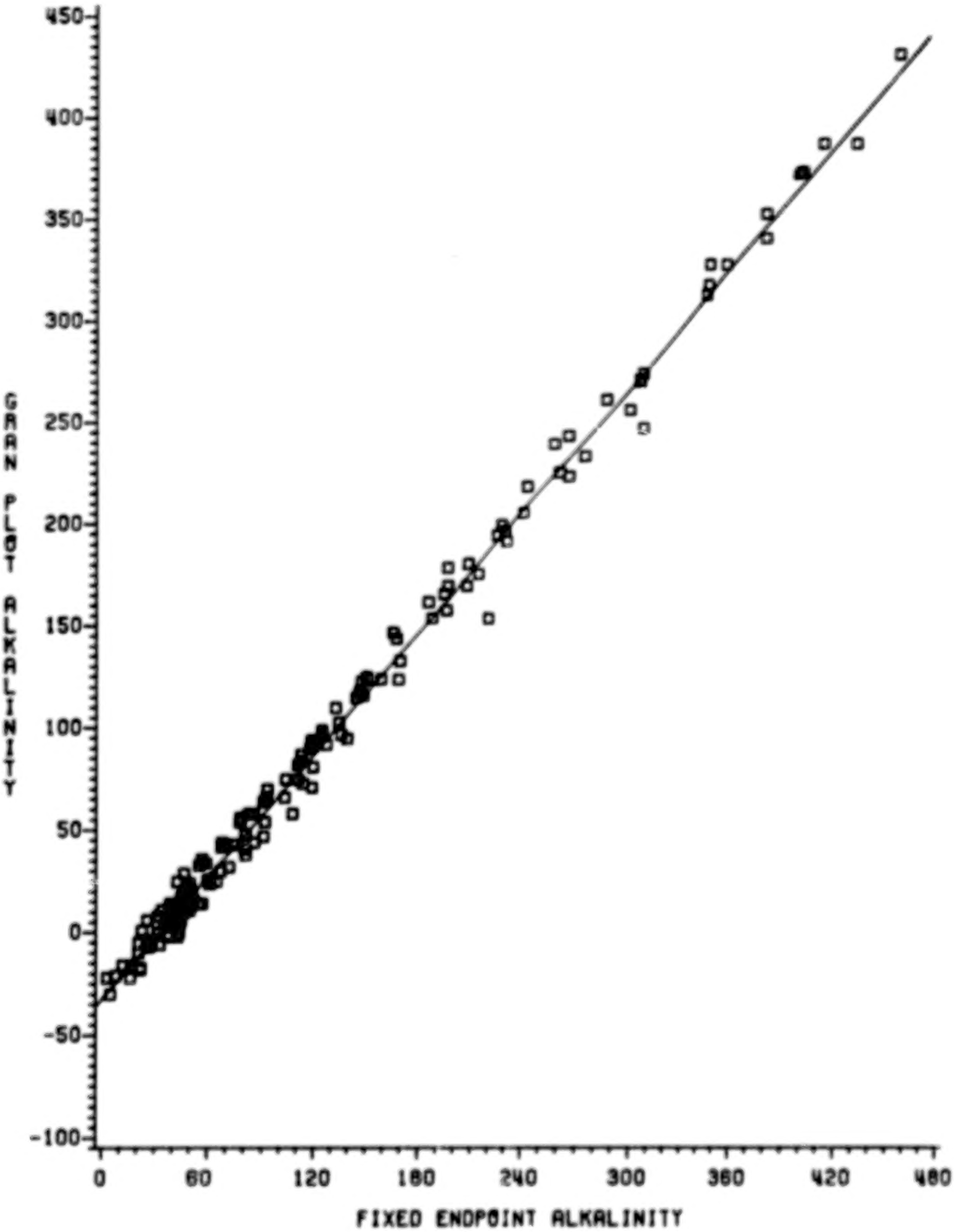

Figure 36. Inflection point (Gran plot) versus fixed endpoint (pH 4.5) alkalinity for 184 sample sites. Least squares regression equation: IP = -32 + 1.00 FP ($\underline{r}^2$ = 0.999).

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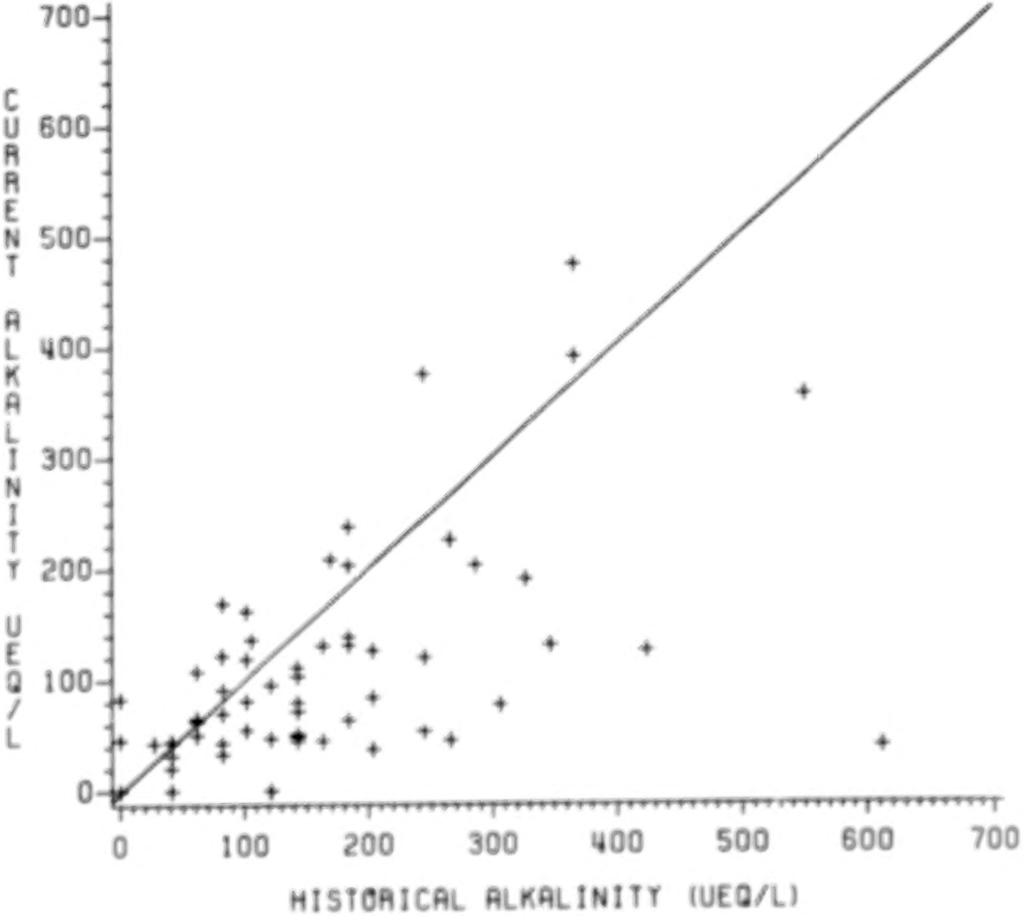

Figure 37. Current versus historical alkalinity for 56 New England lakes. Solid line indicates equivalent alkalinity.

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was no discernable relationship between time interval between measurements and magnitude of the change in alkalinity. The change in alkalinity agrees well with the change in pH and indicates comparable levels of acidification.

Because historical alkalinity data are scarce, other comparisons of historical and recent alkalinity data are rare. Morling (1981) reported annual alkalinity measurements for four Swedish lakes from 1967-1968 to 1979. All declined by 10 to 20 µeq $l^{-1}$. Lewis (1982) reported that alkalinity averaged 440 µeq $l^{-1}$ in 64 Colorado lakes during 1938-1960, and averaged 360 µeq $l^{-1}$ in 1979. McColl (1981) analyzed weekly alkalinity data over the period 1944-1979 for one reservoir in the Sierra Nevada mountains of California. Alkalinity decreased from about 350 µeq $l^{-1}$ to about 230 µeq $l^{-1}$. During the period 1954 to 1979, for which hydrogen ion measurements were also available, alkalinity declined about 90 µeq $l^{-1}$.

## Multivariate Analyses

The large number of factors measured in this study makes the identification of key variables difficult. A number of multivariate analytical methods were explored in an attempt to reduce the complexity of the data set and identify the factors that contribute most to the variance.

### Principal Components

Principal Components Analysis (PCA) is a procedure that reduces a large set of intercorrelated variables to a smaller set of hypothetical variables, each of which is independent of the others. PCA forms successive linear combinations of original variables that "account" for decreasing amounts of variation in the original data set. The problem of different units for different variables can be eliminated by standardizing the variables with respect to the mean. We applied PCA to the standardized water chemistry data in an attempt to identify the chemical factors that could best be used to categorize surface waters with respect to vulnerability to acidification.

The results of the PCA for standardized major water chemistry factors (Table 20) define three axes that account for 71% of the population variance. The variable weights are defined such that the sum of the weights squared equals one. Thus the weight is an index of the proportion of the variance accounted for by the principal component that is attributed to the individual variable. PC1 is dominated by the factors pH, alkalinity, calcium, and sulfate. These factors are related to acidity and buffering capacity. PC2 is dominated by chloride, sodium, and potassium in an inverse relationship, as these weights are negative. These are neutral ions that contribute to ionic strength but not to acidity or buffering capacity. PC3 is dominated by the metals aluminum and manganese.

Table 20. Principal Component Analysis of Standardized Major Water Chemistry Factors of New England Lakes. Analysis Included Only Lakes with Ion Balance of 0 ± 75 μeq $l^{-1}$

| Variables | Variable weights for principal components | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| PH | 0.46 | 0.12 | -0.16 |
| Alkalinity | 0.49 | 0.25 | 0.14 |
| Calcium | 0.51 | 0.25 | 0.08 |
| Chloride | 0.16 | -0.57 | -0.02 |
| Sodium | 0.17 | -0.56 | 0.04 |
| Potassium | 0.27 | -0.45 | 0.22 |
| Sulfate | 0.40 | <0.01 | -0.22 |
| Aluminum | -0.05 | 0.08 | 0.55 |
| Manganese | 0.03 | 0.05 | 0.74 |
| % Variance explained by each PC | 34 | 58 | 71 |

Next, the PCA scores for each lake were considered as the observed variables and compared to bedrock geology and soil class for each sample (Table 21). The mean values for PC1 increase with increased bedrock buffering capacity, but PC2 and PC3 do not show consistent trends. The relationship of bedrock class to principal component variables was tested with analysis of variance. Bedrock classes 1 and 2 were not significantly different from each other ($\underline{p} = 0.10$), but all other possible contrasts were different ($\underline{p} < 0.01$). For soil class only PC2 consistently increases with increasing cation exchange capacity (Table 21). Analysis of variance shows that soil classes $SS_1$ and $SS_2$ were not significantly different from each other ($\underline{p} = 0.61$), but both were different from class NS ($\underline{p} < 0.001$).

Based upon the groupings of chemical factors suggested by the above PCA, we conducted another analysis on a reduced data set. We defined four variables: alkalinity factor (sum of H ion, alkalinity, and Ca in $\mu eq\ l^{-1}$), salts (sum of Cl, Na, and K in $\mu eq\ l^{-1}$), sulfate ($SO_4$ concentration, $\mu eq\ l^{-1}$), and metals (sum of Al and Mn, $\mu eq\ l^{-1}$). We used only lakes where the difference of anions and cations was 0±75 $\mu eq\ l^{-1}$. The results of this analysis (Table 23) show that the first two PC factors account for nearly all (>99%) of the variance. PC1 is dominated by alkalinity and PC2 by salts. These are the factors that also dominated the first two PC factors in the previous PCA. Note that PC1 (alkalinity) accounts for 88% of the variance. PC factors 3 and 4, although they contribute very little to the variance, are dominated by sulfate and metals respectively. These results indicate that the alkalinity factors -- pH, alklinity, and calcium -- are the most important chemical factors in lake classification.

## Canonical Analysis

In canonical analysis two sets of variables are transformed such that the correlation of the two sets is maximized. This is done by applying a weighting factor to each variable in each set. By examining the weights applied to each variable one can ascertain which variables are most important in describing the variations in the data. Unlike principal components, however, the magnitude of the coefficients is not constrained. Thus, they cannot be used to directly estimate the proportion of canonical correlation attributable to each variable.

Canonical analysis was used to relate physical factors such as bedrock and soil class, elevation, etc. to lake chemistry factors. The results (Table 23) show that reasonably high correlation ($\underline{r}_1 = 0.70$, $\underline{r}_2 = 0.56$) exists between physical and chemical factors. The correlation coefficients were statistically significant for variables 1 and 2 (Bartletts test, $\underline{p} < 0.001$). The physical factors with highest weights in canonical variable 1 are bedrock and soil class; the highest weighted chemical factors were calcium and alkalinity in the chemical set. Variable 2 assigned highest weights to elevation in the physical set and to calcium and alkalinity in the chemical set.

Table 21. Mean Principal Component Values for Bedrock and Soil Classes

| | Principal component | | |
|---|---|---|---|
| Bedrock class | 1 | 2 | 3 |
| 1 | -0.89 | -0.23 | 0.10 |
| 2 | -0.16 | 0.17 | -0.03 |
| 3 | 1.47 | <0.01 | 0.09 |
| 4 | 4.68 | 1.56 | 0.52 |
| Soil class | | | |
| $SS_1$ | 0.04 | -0.88 | 0.09 |
| $SS_2$ | -0.57 | -0.64 | -0.07 |
| NS | 0.25 | 0.67 | -0.01 |

Table 22. Principal Components Analysis of Combined Chemical Factors. All Units were $\mu eq\ l^{-1}$. The Factors were Defined: Alkalinity = Sum of H, Alkalinity, Ca; Salt = Sum of Cl, Na, K; Sulfate = $SO_4$; Metal = Sum of Al, Mn

| | Principal component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Variable weight | | | | |
| Alkalinity | 0.999 | 0.016 | -0.041 | 0.003 |
| Salt | -0.016 | 0.999 | -0.022 | 0.003 |
| Sulfate | 0.040 | 0.023 | 0.999 | -0.006 |
| Metal | -0.002 | -0.003 | 0.006 | 0.999 |
| % Variance | 88.36 | 99.67 | 99.98 | 100.00 |

Table 23. Canonical Analysis of Physical and Chemical Factors for New England Lakes

| | Canonical variable | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Physical factor weights | | | | |
| Area | -0.14 | -0.03 | 0.14 | 1.03 |
| Hydrology type | -0.22 | -0.16 | -0.27 | 0.52 |
| Elevation | -0.38 | 0.63 | -0.95 | 0.03 |
| Bedrock class | 0.68 | 0.23 | 0.09 | 0.20 |
| Soil class | 0.50 | 0.27 | 0.49 | -0.20 |
| Disturbance code | 0.35 | -0.33 | -0.83 | 0.02 |
| Chemical factor weights | | | | |
| PH | 0.22 | 0.26 | -0.33 | 1.01 |
| Alkalinity | -0.63 | -1.80 | -0.96 | -0.61 |
| Specific conductance | -0.11 | -0.49 | 0.75 | 0.74 |
| Aluminum | 0.17 | 0.30 | -0.51 | 0.04 |
| Calcium | 1.12 | 2.14 | 0.54 | -0.71 |
| Chloride | -0.31 | -0.25 | 0.12 | 0.47 |
| Color | 0.15 | -0.03 | 0.06 | -0.62 |
| Potassium | 0.15 | -0.02 | -0.61 | -0.41 |
| Magnesium | 0.24 | 0.17 | -0.23 | 0.10 |
| Manganese | -0.03 | -0.06 | -0.40 | -0.10 |
| Sodium | 0.34 | -0.50 | 0.02 | -0.49 |
| Sulfate | 0.31 | -0.21 | 0.39 | -0.01 |
| Cannonical correlations | 0.70 | 0.56 | 0.42 | 0.31 |

Relationships between the hypothetical canonical variates and the variables in the set that comprise it were investigated by computing the correlation of each variable in the set with each canonical variate, following the method of Timm (1975). These results (Table 24) show bedrock class and disturbance code to be the most important physical factors in canonical variable (CV) 1. Among chemical factors, specific conductance, calcium, alkalinity, sulfate, magnesium, and pH were most important. These are the same chemical factors that dominate principal component 1.

For CV2, elevation and soil type dominated physical factors and chloride, sodium, and potassium dominated chemical factors. The chemical factors are the same as those dominating principal component 2. The importance of bedrock and soil class in relation to lake chemistry is confirmed. The importance of elevation in these analyses may be the result of an interaction between elevation and bedrock and soil classes.

### Cluster Analysis and Discriminate Functions

Application of cluster analysis and distriminate function analysis did not produce useful results. Discriminate functions could not classify surface waters to clusters with better than 50% accuracy. No rational basis for formation of clusters could be elucidated, and consequently these approaches were abandoned.

## MODELS OF ACIDIFICATION

### Henriksen Models

Henriksen (1979, 1980) proposed that ionic composition of surface waters, corrected for marine aerosols, could be used to determine whether acidification had occurred. In unacidified waters calcium and magnesium are the major cations and bicarbonate is the major anion. The regression of calcium plus magnesium on alkalinity, forced through the origin, produced the relationship alkalinity = 0.91 (Ca + Mg). As the ratio of calcium to magnesium is relatively constant over a wide range of concentrations, calcium can be substituted for the sum of calcium and magnesium.

Henriksen (1979, 1980) hypothesized that the acidification of lakes was analogous to titration of a bicarbonate solution with a strong acid. The first stage of titration he termed bicarbonate lakes, with pH above 5.5. The second stage was termed transition lakes, characterized by depletion of bicarbonate and pH fluctuations in the range of pH 5.0-5.5. The third stage was termed acid lakes, with no bicarbonate, excess hydrogen ion and ionic aluminum, and pH below 5.0. Working with surface water chemistry data sets from regions experiencing a gradient in sulfate deposition, two empirical relationships were derived that relate lake acidification to ionic composition. The first relates non-marine calcium concentration to lake pH. An empirical curve was derived based on the relationships of calcium and pH to alkalinity, separating lakes into two

Table 24. Correlations Between Canonical Variates and Individual Variables, Derived from the Standard Coefficients in Table 21 and the Simple Correlation Matrix

| | Canonical variable | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Physical factors | | | |
| Area | -0.02 | 0.13 | 0.20 |
| Hydrology | -0.18 | -0.13 | -0.24 |
| Elevation | -0.19 | 0.90 | -0.38 |
| Bedrock class | 0.81 | 0.27 | -0.11 |
| Soil class | 0.29 | 0.67 | 0.19 |
| Disturbance | 0.54 | -0.55 | -0.55 |
| % Variance explained | 18.3% | 27.8% | 9.9% |
| Chemical factors | | | |
| PH | 0.59 | 0.03 | -0.23 |
| Alkalinity | 0.74 | 0.08 | -0.23 |
| Specific conductance | 0.88 | -0.78 | -0.04 |
| Aluminum | 0.05 | 0.17 | -0.40 |
| Calcium | 0.84 | 0.16 | -0.04 |
| Chloride | 0.09 | -0.80 | 0.06 |
| Color | 0.02 | -0.15 | 0.02 |
| Potassium | 0.35 | -0.54 | -0.39 |
| Magnesium | 0.64 | -0.24 | -0.28 |
| Manganese | 0.27 | -0.04 | -0.23 |
| Sodium | 0.26 | -0.87 | -0.10 |
| Sulfate | 0.71 | 0.04 | 0.37 |
| % Variance explained | 29.6% | 16.0% | 5.9% |

groups. The groups of lakes that plot below the empirical line have pHs in the range expected based on the calcium concentration and associated alkalinity. Lakes that plot above the line have pHs lower than predicted from the calcium - alkalinity - pH relationships for undisturbed lakes. This would result if addition of acid reduced the alkalinity and pH below that which would normally be associated with the calcium content, and calcium content itself was not affected.

Application of this pH-calcium nomogram to data for New England lakes with non-marine calcium of 500 $\mu eq\ l^{-1}$ or less (Figure 38) indicates that slightly more than half of the lakes (80 of 140; 57%) fall above the empirical line and are presumably acidified to some degree. This is similar to the percentage of lakes in the historical pH data set that are now lower in pH (see Figure 33). In our data set, pH is significantly related to alkalinity (Figure 39). The relationship differs from the theoretical relationship. At atmospheric $CO_2$ (partial pressure $10^{-3.5}$ atm), the theoretical relation is pH = 11.3 + log $(HCO_3^-)$. The difference in our data may be the result of higher partial pressure of $CO_2$ in these waters or of organic acids.

The second empirical relationship derived by Henriksen (1982) uses the relationship of calcium or calcium plus magnesium concentration to sulfate concentration to predict lake pH. Lakes are separated into three groups. Bicarbonate lakes have low sulfate content, significant acid neutralizing capacity, and pHs generally above 5.5. Transitional lakes have intermediate sulfate content, have lost most acid neutralizing capacity, and have varying pH, but generally between 5.0 and 5.5. Acid lakes have no acid neutralizing capacity, high sulfate and ionic aluminum content, and pHs generally below 5.0. Henriksen (1980) used empirically derived equations equivalent to pH 4.7 and 5.3 to divide lakes into these three groups.

Application of the calcium - sulfate relationships to data from New England lakes with calcium plus magnesium and sulfate concentrations below 400 $\mu eq\ l^{-1}$ (Figure 40) did not agree well with measured data (Table 25). The model predicts pH to be much lower than was actually the case. One reason for this may be high background sulfate concentrations in New England as compared to Scandinavia. Accordingly, non-marine sulfate was adjusted by subtracting 50 $\mu eq\ l^{-1}$ as the best estimate of background sulfate (see Figure 14) to yield net sulfate. Further, the lakes were divided into three pH categories pH $>5.5$, pH = 5.0-5.5, and pH $<5.0$, and a linear regression was run on calcium plus magnesium against net sulfate for lakes in the pH range 5.0-5.5. This produced the regression: Ca + Mg = (1.18 net sulfate) -9.9. The regression is significant ($r^2 = 0.67$, $\underline{p} = 0.0001$, N = 23). This regression line was used to divide the lakes into two groups: pH $>5.5$ and pH $<5.0$. The transitional lakes (pH 5.0-5.5) are plotted but are not included in the analysis. Application of this model to our data (Figure 41) produces excellent results (Table 25). Acid and bicarbonate lakes are separated nearly completely. The transitional lakes are highly variable in pH.

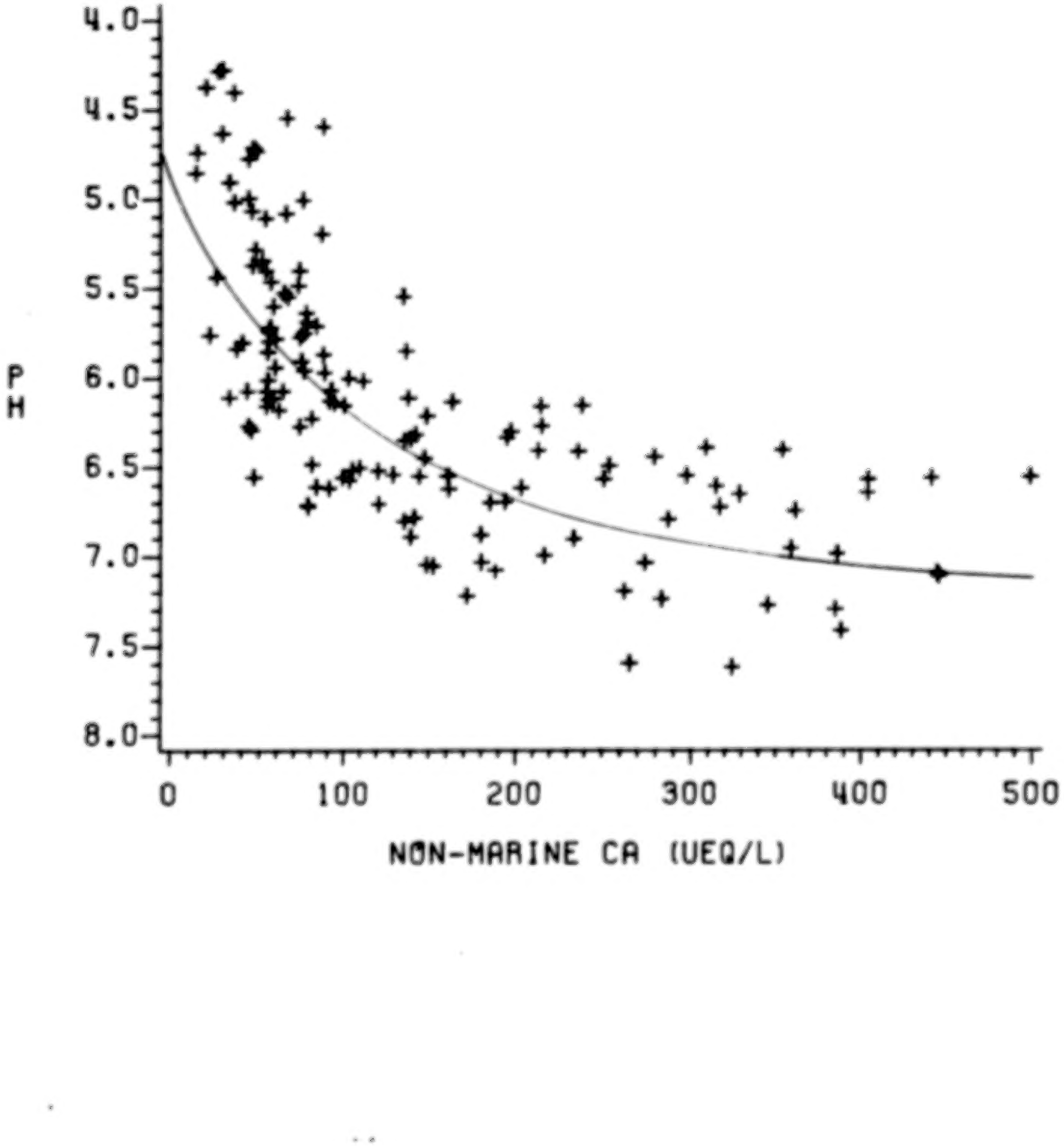

Figure 38. Henriksen calcium-pH model applied to 140 New England surface waters having calcium concentrations 500 µeq $1^{-1}$.

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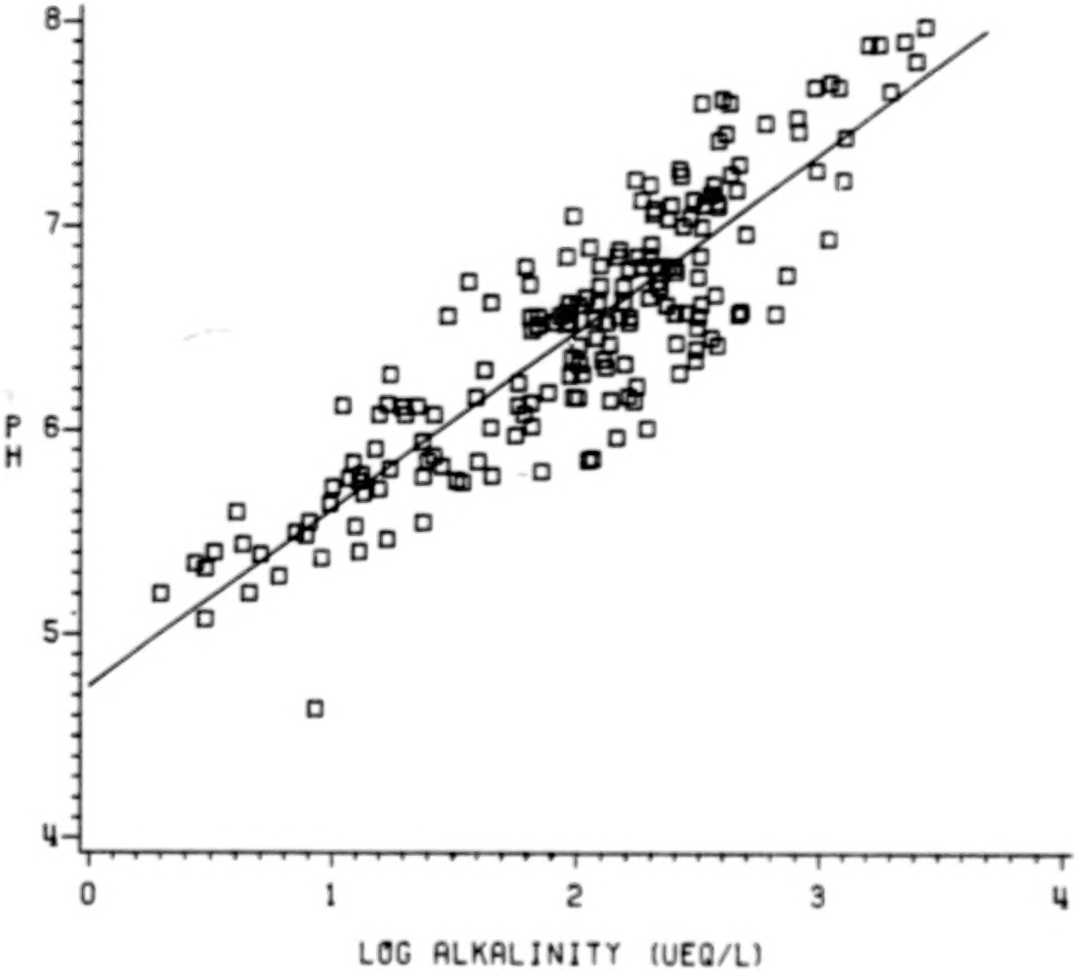

Figure 39. Relation of pH to $\log_{10}$ alkalinity in 182 New England lakes. The regression equation is pH = 4.75 + 0.87 log alkalinity, $r^2 = 0.78$, $p = 0.0001$, computed from the mean of two replicates and averaging surface and deep samples where taken.

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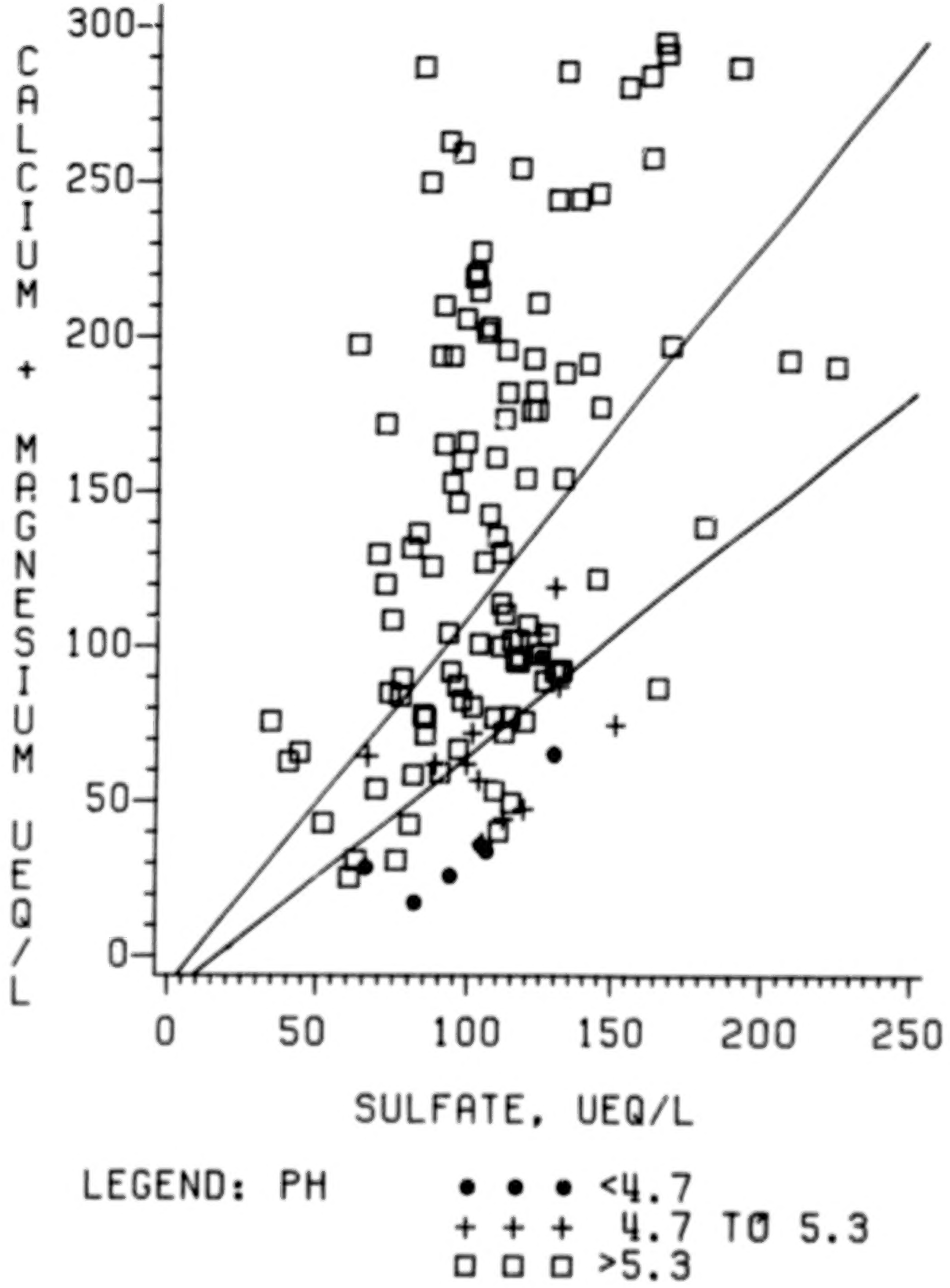

Figure 40. Henriksen sulfate-pH model applied to 120 New England lakes having calcium plus magnesium concentrations 400 $\mu$eq $l^{-1}$. Solid lines indicate regressions for waters of pH 4.6-4.8 (4.7) and 5.2-5.4 (5.3), after Henriksen (1980).

Table 25. The Prediction of PH of New England Lakes by Henriksen's Nomograph and the Actual PH of these Lakes for Original and Adjusted Sulfate Values

| Original Nomograph | pH Range | | |
|---|---|---|---|
| | <4.7 | 4.7-5.3 | >5.3 |
| Number in pH range | 7 | 14 | 101 |
| Predicted number in pH range | 25 | 37 | 60 |
| Predicted correctly | 6 | 5 | 60 |
| Percent predicted correctly | 24% | 14% | 100% |

| Modified Nomograph | pH Category | |
|---|---|---|
| | <5.0 | >5.5 |
| Number in pH category | 16 | 94 |
| Predicted number in pH category | 16 | 94 |
| Predicted correctly | 14 | 92 |
| Percent predicted correctly | 88% | 98% |

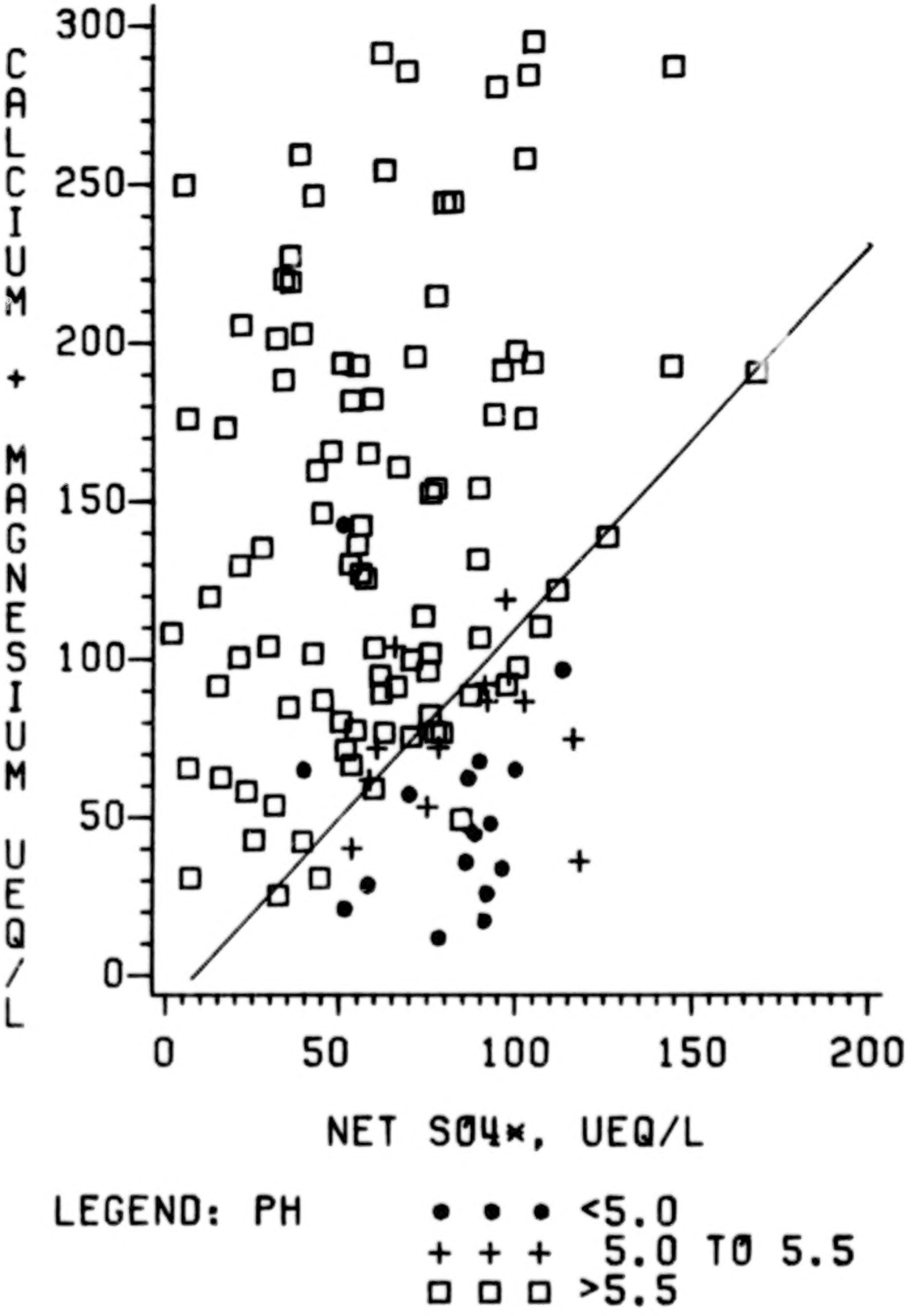

Figure 41. Henriksen sulfate - pH model as in Figure 40, except sulfate is corrected by subtracting 50 μeq $l^{-1}$ background, resulting in net non-marine sulfate. The equation of the regression line is given in the text.

This is reasonable considering that the lakes were sampled only once and lakes in this category will vary greatly in pH depending on recent climatological and hydrological events.

Henriksen (1980) further proposed that the calcium - sulfate model could be used to predict pH of lakes if sulfate deposition were to change. This approach is based on two assumptions: 1) lake acidification is related to atmospheric deposition of sulfate, and 2) the concentrations of calcium and magnesium will not change if sulfate deposition changes. In southern Norway there is a steep gradient in sulfate deposition rate moving from south to north, and lake acidification is highly correlated with sulfate in precipitation (Wright et al. 1977; Henriksen 1979). In New England, however, sulfate deposition is relatively uniform, ranging only from 40 to 60 kg $ha^{-1}$ $yr^{-1}$ (National Atmospheric Deposition Program 1981). Attempts to relate sulfate deposition to lake sulfate concentration or hydrogen ion concentration were not successful. However, Wright (R. Wright, Norwegian Institute of Water Research, personal communication) has compared atmospheric sulfate deposition to lake sulfate concentration for a number of areas in North America and found a significant correlation. These data sets covered a larger gradient in sulfate deposition than exists in New England.

If lake calcium and magnesium content change with changes in acid loading, estimates of preacidification alkalinity will be in error. Given that ionic balance must be preserved, the addition of sulfuric acid to a lake may result in a decrease in bicarbonate concentration, an increase in cation concentration (primarily calcium and magnesium), or both . Henriksen (1982) examined a number of data sets; some showed no change in calcium or magnesium concentration with increased acid loading but some showed an increase. The maximum increase in calcium plus magnesium concentration was equivalent to 0.4 times net non-marine sulfate concentration.

Wright (personal communication) has extended the approach of Henriksen to a more generalized acidification equation: $0.91\ (Ca^* + Mg^*) - HCO_3 + H + Al = \text{net } SO_4^*$ where the asterisk denotes that concentrations have been corrected for marine aerosols. The left side of the equation represents loss of alkalinity, or acidification, which is balanced by input of sulfate. The relation between the various components of the loss of alkalinity term will vary. H and Al will only be important below pH 5.0, and $HCO_3$ will only be important above this pH. $Ca^* + Mg^*$ may change, probably within the range of 0 to 0.4 times net $SO_4^*$, but the actual change cannot be predicted at present.

For New England lakes with $Ca^* + Mg^*$ and net $SO_4^*$ below 400 μeq $l^{-1}$ the average calculated loss of alkalinity is 50.3 μeq $l^{-1}$, and the average calculated net $SO_4^*$ is 61.6 μeq $l^{-1}$. These values are not different statistically (paired to test,

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$t = -1.46$, $p = 0.15$, $N = 168$), as expected. However, the regression of loss of alkalinity on net sulfate for individual lakes is likewise not significant (loss of alkalinity = 27.6 + 0.36 net $SO_4$ , $r^2 = 0.05$). This is probably the result of variability in lake chemistry, hydrology, climatology, etc. The data we have are not precise enough to adequately apply the acidification equation to an individual lake. However, the equation does appear to apply to the average condition in lakes in the region, and may be applied to predict average changes on a regional, but not individual lake, basis.

To apply the acidification equation as a predictor equation the following relationships are employed (R. Wright, personal communication). The fraction of the change in net $SO_4$ that is compensated by change in Ca = Mg is given by the factor F, which varies between 0 and 0.4: $(Ca + Mg)_p = (Ca + Mg)_t \times F$ (change in net $SO_4$ ) where the subscripts p and t denote predicted and today, respectively, Lakes above a threshold level of (Ca + Mg ) will still have bicarbonate and pH will be above 5.5. Lakes below this threshold will generally be below pH 5.0. The threshold (Ca + Mg ) will be related to net $SO_4$ : threshold (Ca + Mg ) = 1.1 (net $SO_4$ ) where the factor 1.1 is derived from 1/0.91. A change in net $SO_4$ loading will change the threshold Ca + Mg .

The predicted portion of New England lakes that will be acidic based on these relationships and for various levels of net $SO_4$ are shown in Figure 42. In Figure 42a the factor F = 0 is used and in Figure 42b the factor F = 0.4. Sulfate = 60 represents present conditions in New England where calculated average net $SO_4$ is 60 $\mu eq\ l^{-1}$. Sulfate = 30 and Sulfate = 120 represent a halving and doubling of net $SO_4$ , respectively. For F = 0, the model predicts that 16.2% of the lakes will be acidic ($pH < 5$) at the present net $SO_4$ of 60 $\mu eq\ l^{-1}$. The actual portion of lakes that were $pH < 5$ was 8%. Thus the model overestimates the proportion of acidic lakes. However, for F = 0.4 the model predicts that 7.5% of lakes would be acidic under present conditions, a value in excellent agreement with that observed. If net $SO_4$ is increased to an average of 120 $\mu eq\ l^{-1}$, the model predicts 31.6% of New England lakes will be acidic. Conversely, if the average net $SO_4$ were to drop to 30 $\mu eq\ l^{-1}$, the percent of lakes that are predicted to be acidic declines to 3.6%.

## Kramer Model

Kramer and Tessier (1982) proposed that all cations should be considered in chemical acidification models, not just calcium or calcium plus magnesium. The theoretical relation between pH and the sum of cations can be calculated from equations representing carbonic acid weathering reactions, holding $Pco_2$ constant. Lakes that deviate from the theoretical line would then represent either an input of hydrogen ion or an additional neutralizing substance.

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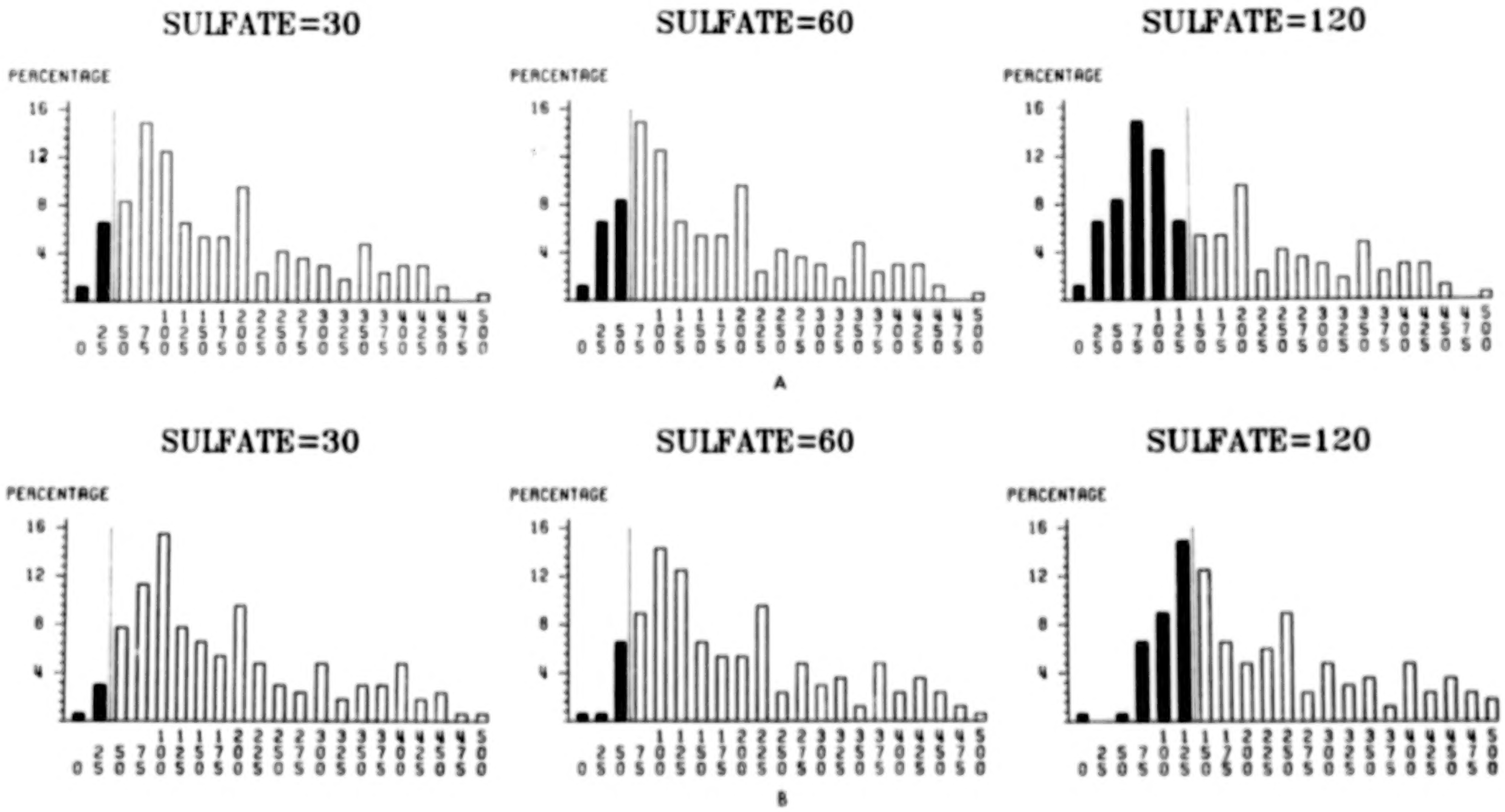

Figure 42. Frequency distribution of lakes in intervals of 25 μeq l$^{-1}$ calcium plus magnesium. In section A a correction factor F = 0 is used, and in section B F = 0.4 is used. The calcium plus magnesium threshold between acid and bicarbonate lakes is indicated by the vertical line for present net sulfate concentration (60 μeq l$^{-1}$) and the projected threshold is indicated for net sulfate concentrations half (30 μeq l$^{-1}$) and double (120 μeq l$^{-1}$) present levels. Shaded bars indicate lakes that are predicted to be pH < 5.

The application of this model to the data for New England (Figure 43) shows that samples with high cation content and high pH plot very close to the line. As cation concentration decreases, the points increasingly deviate from the line. The deviation above the line indicates an excess of hydrogen ion over that predicted from carbonic acid weathering. Acidification was arbitrarily defined as a deviation of more than 0.5 pH unit from the predicted pH. In our data, 48 of 191 (25%) lakes and streams were classified as acidified by this criterion. Many of the acidic lakes fall in this category and are presumably acidified as the result of atmospheric deposition. However, some of the most acidic lakes in our samples do not fit this model very well. Actual $Pco_2$ in the sample was calculated from the equation $pPco_2$ = pH measured - pK + $pHCO_3^-$ where p signifies the negative log and pK = 7.75. The measured pH was then corrected by normalizing $Pco_2$ to $10^{-2.5}$ atm., using the equation pH corrected = pH measured + 2.5 $pPco_2$ where 2.5 is the negative log of $10^{-2.5}$, and $pPco_2$ is the value calculated as described above. Some acidic samples had a very low calculated $Pco_2$, resulting in a very large pH correction. Inasmuch as $Pco_2$ was not measured directly, it is not known whether this correction is realistic.

## Thompson Model

Thompson (1982) has proposed a cation denudation model of acidification, which can be expressed as a rate model or a concentration model. The rate model depicts the export of cations from a watershed in runoff. This model is very similar to the Henriksen model, except that the sum of cations replaces the sum of calcium and magnesium, and pH is predicted theoretically rather than empirically. The model allows prediction of pH based upon the relationship between bicarbonate ion and hydrogen ion in the carbonic acid system: pH = pK + $pPco_2$ - $pHCO_3^-$. In this model, pK is assumed to be 7.75 and $pPco_2$ is set at 2.5, which is reasonable for our samples based on the calculated values of $Pco_2$ obtained above. The model assumes that the cations are balanced by sulfate and bicarbonate. Sulfate is assumed to originate from atmospheric deposition (all ions are corrected for marine aerosols), and no correction for background sulfate is applied.

The application of this model to our data (Figure 44) gives fair results. Lower pH lakes generally fit the model better than higher pH lakes (Table 26). Subtraction of background sulfate does not improve the fit of the model significantly. This model depends on the relation of excess sulfate to acidification, as does the Henriksen model. As such, it could be used to predict pH changes for given sulfate loads if the relation between surface water sulfate content and atmospheric deposition of sulfate were known. This model assumes that cations will be mobilized by sulfate and therefore does not depend on stable cation concentrations. The cation denudation model can also be used to predict the amount of acidification that has already occurred. All points falling below the 5.1 line have cations in excess of bicarbonate and are presumed to be

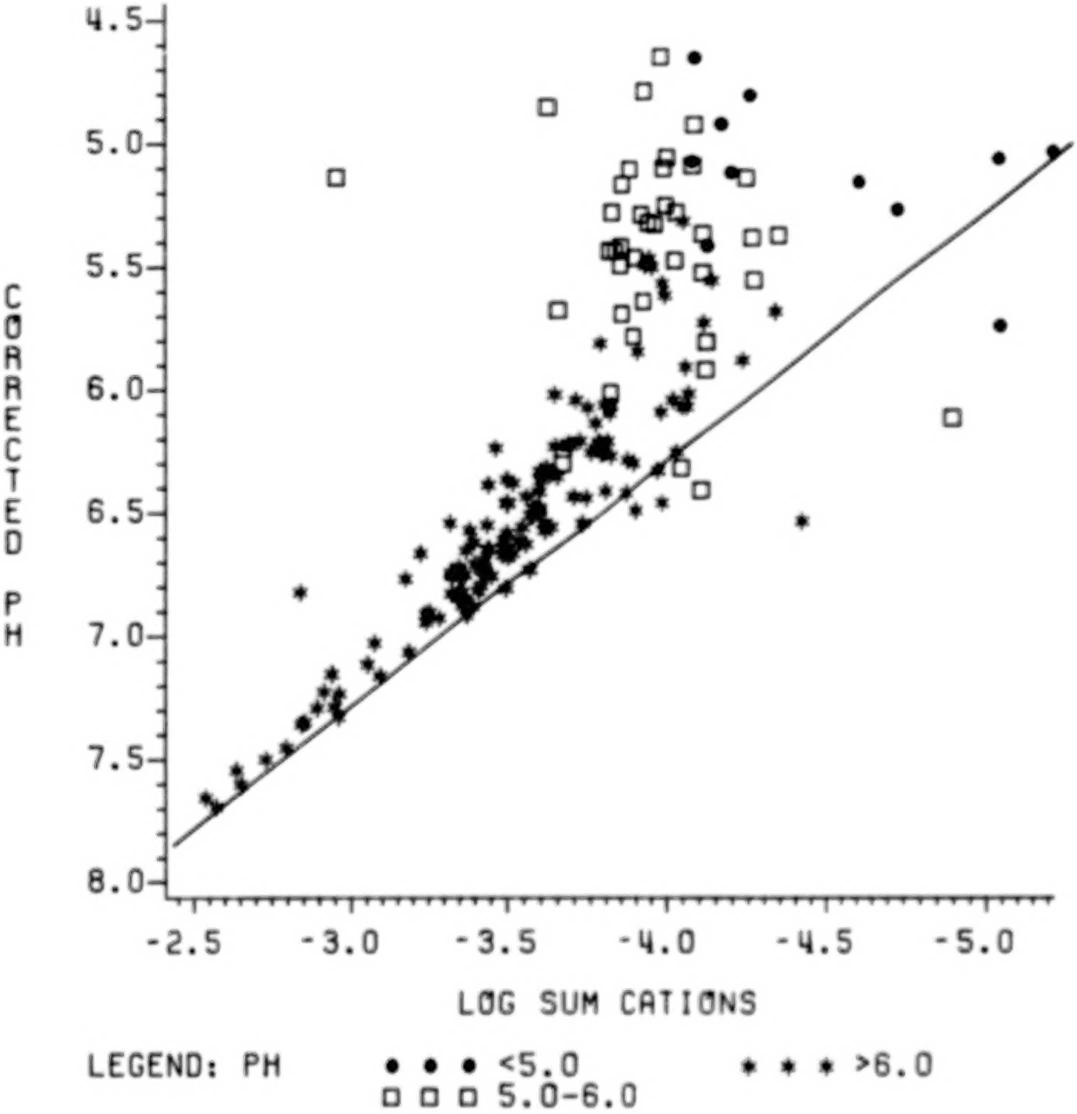

Figure 43. Application of the Kramer model to 191 New England lakes and streams. The diagonal line is the computed relation for carbonic acid weathering assuming a $P_{CO_2}$ of $10^{-2.5}$ atm.

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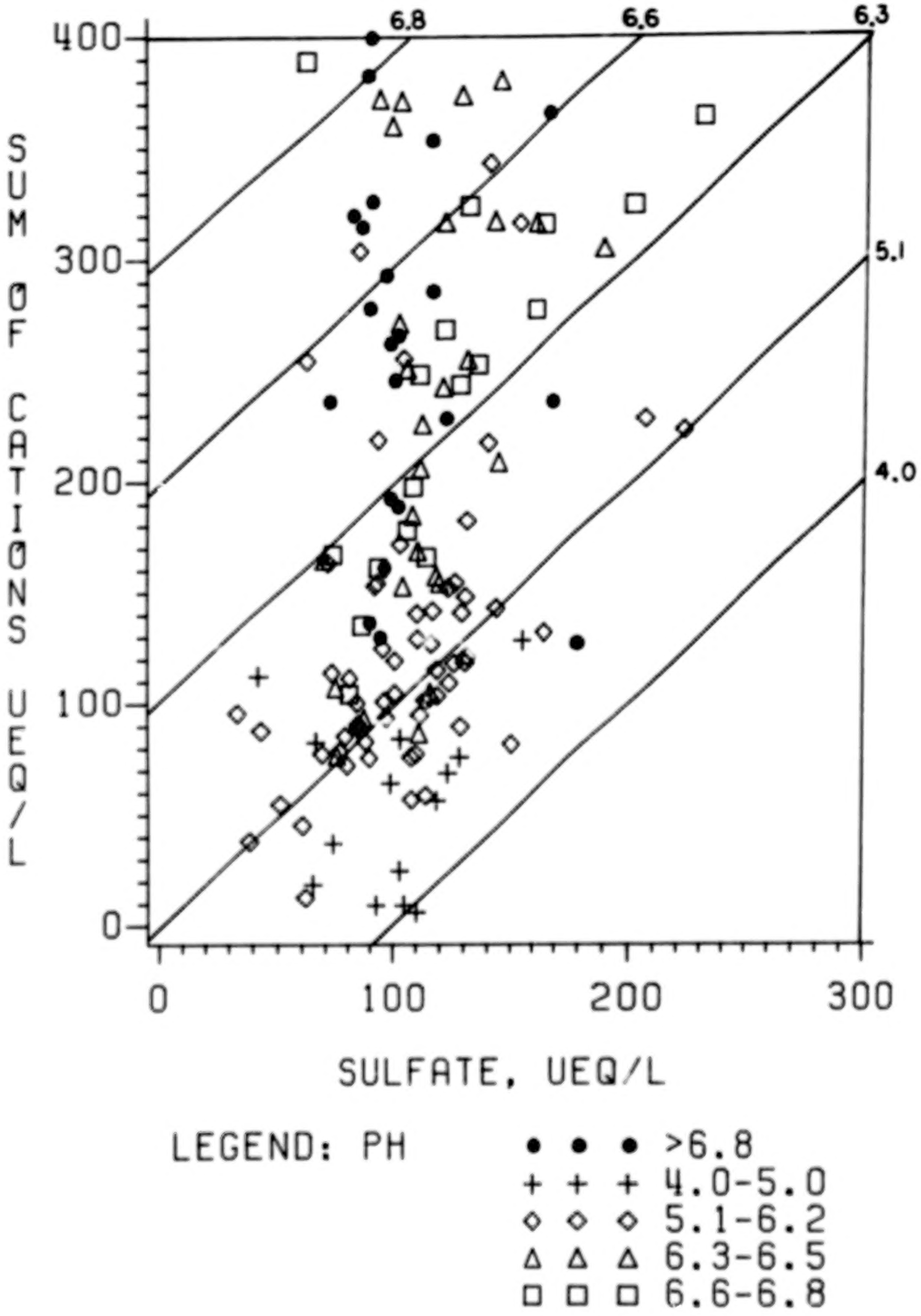

Figure 44. Application of the Thompson model for 142 New England lakes and streams. Samples with $\Sigma$ cations greater than 400 $\mu$eq l$^{-1}$ were omitted. Measured mean pH is shown by the symbols.

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Table 26. The Prediction of PH in New England Lakes and Streams by Thompson's Cation Denudation Model

| | PH range | | | | |
|---|---|---|---|---|---|
| | 4.0-5.0 | 5.1-6.2 | 6.3-6.5 | 6.6-6.8 | >6.8 |
| Measured sulfate | | | | | |
| Actual number in pH range | 16 | 60 | 27 | 20 | 19 |
| Number predicted in pH range | 36 | 57 | 33 | 14 | 2 |
| Number predicted correctly | 14 | 34 | 6 | 2 | 1 |
| Percent predicted correctly | 39% | 60% | 6% | 14% | 50% |

acidified. The deviation below the line is an indicator of the degree of acidification. On this basis, 36 of 142 (25%) of the lakes and streams we surveyed would be classed as acidified. This is a smaller proportion than that predicted by the Henriksen model, but agrees well with the Kramer model.

# CONCLUSIONS

A substantial portion of the surface waters in New England that were not affected by direct human disturbance were found to be very low in acid neutralizing capacity and therefore vulnerable to acidification. Approximately half of the waters surveyed were classed as vulnerable by several indicators, including alkalinity, calcium, and Calcite Saturation Index. The vulnerable waters were located in clusters. The locations of the clusters generally coincided with areas underlain by bedrock that was low in acid neutralizing capacity. Both comparisons with historical water chemistry data and application of chemical models of acidification indicated that approximately 60% of the waters surveyed had been acidified, as indicated by a reduction in pH, alkalinity, or both. Presently about 8% of the waters surveyed were acidic ($pH \leq 5.0$), had elevated aluminum concentration ($>200\ \mu g\ l^{-1}$), or both, conditions that may be toxic to sensitive fish species.

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# APPENDIX A

The data collected are presented in tabular form, subdivided by state. For each state the following information is presented:

| | |
|---|---|
| water code | a unique code number assigned to each water sampled |
| name: | the name of the water |
| date: | date the water was sampled |
| latitude and longitude: | the location of the water in degrees, minutes and seconds of latitude and longitude |
| elevation: | elevation of water in meters |
| area: | the area of lakes, in hectares, or width, in meters, for streams |
| type: | 1 = lake, 2 = stream, 3 = impoundment |
| hydrology: | 1 = first order stream, 2 = second order stream, 3 = third order stream, 4 = fourth order stream, 5 = drainage lake, 6 = seepage lake |
| bedrock: | 1 = very low in buffering capacity 2 = moderately low, 3 = moderately high, 4 = very high |
| soil type: | 1 = S1, sensitive; 2 = S2, sensitive 50%; 3 = SS1, slightly sensitive; 4 = SS2, slightly sensitive 50%; 5 = NS, mostly non-sensitive |
| disturbance: | 1 = more, 2 = slight, 3 = moderate, 4 = high |

| | |
|---|---|
| precipitation pH: | mean weighted annual pH of precipitation as obtained from maps produced by the National Atmospheric Deposition Program |
| annual precipitation: | amount, in mm, for the most recent year available as recorded at the nearest U.S. Weather Bureau station |
| depth: | depth at which the sample was collected, in meters |
| temperature: | temperature of water at the time of collection, in degrees celcius |
| pH: | pH of water sample, measured in replicate |
| fixed endpoint alkalinity: | alkalinity of water sample determined by titration of pH 4.5, μeq l$^{-1}$, in replicate |
| inflection point alkalinity: | alkalinity of water sample determined by Gran titration, μeq l$^{-1}$, in replicate |
| specific conductance: | specific conductance of water sample, μSiemens cm$^{-1}$ at 25°C, in replicate |
| color: | apparent color of water sample (unfiltered) by comparison to platinum-cobalt standards, color units, in replicate |
| chloride: | chloride concentration of water sample, mg l$^{-1}$, in replicate |
| sulfate | sulfate concentration of water sample, mg l$^{-1}$, in replicate |
| aluminum: | aluminum concentration of water sample, μg l$^{-1}$, average of five measurements |
| calcium: | calcium concentration of water sample, mg l$^{-1}$, average of five measurements |

potassium: potassium concentration of water sample, mg $l^{-1}$, average of five measurements

magnesium: magnesium concentration of water sample, mg $l^{-1}$, average of five measurements

manganese: manganese concentration of water sample, mg $l^{-1}$, average of five measurements

sodium: sodium concentration of water sample, mg $l^{-1}$, average of five measurements

## USFWS ACID RAIN SENSITIVITY PROJECT
## STATE OF CONNECTICUT

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | HYDRO. | BED ROCK | SOIL TYPE | DISTR. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1039 | CLUBHOUSE PD INLET | 81080 | 414159 | 722428 | 171 | 2 | 2 | 1 | 2 | 5 | 2 | 4.3 | 1524 |
| 1096 | BLACKLEDGE R. HDWS. | 81080 | 414536 | 722659 | 178 | 1 | 2 | 1 | 2 | 5 | 2 | 4.3 | 1524 |
| 1098 | DICKINSON CRK. HDWS. | 81080 | 413916 | 722858 | 133 | 1 | 2 | 1 | 2 | 3 | 1 | 4.3 | 1524 |
| 1099 | SALMON RIVER | 81080 | 413057 | 722857 | 6 | 13 | 2 | 4 | 2 | 3 | 3 | 4.3 | 1321 |
| 1100 | SPESTRUM BRK. HDWS. | 81080 | 413221 | 722832 | 55 | 3 | 2 | 3 | 2 | 3 | 2 | 4.3 | 1524 |
| 1101 | MOHAWK PD | 91080 | 414838 | 731737 | 360 | 6 | 1 | 6 | 2 | 3 | 2 | 4.3 | 1524 |
| 1102 | STRAITS PD | 91080 | 414320 | 732230 | 360 | 6 | 1 | 5 | 2 | 3 | 3 | 4.3 | 1524 |
| 1147 | BIGELOW PD | 111280 | 415912 | 720735 | 195 | 7 | 1 | 5 | 2 | 3 | 3 | 4.3 | 1524 |
| 1148 | BLUE PD | 91280 | 413026 | 715353 | 85 | 22 | 1 | 6 | 3 | 4 | 6 | 4.3 | 1321 |
| 1149 | BURR PD | 11280 | 415230 | 730527 | 301 | 34 | 1 | 5 | 2 | 4 | 3 | 4.3 | 1524 |
| 1150 | DARLING PD | 111280 | 414818 | 720735 | 110 | 1 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1524 |
| 1151 | EMMONS PD | 101280 | 420055 | 725411 | 336 | 3 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1524 |
| 1152 | GRIGGS PD | 111280 | 420002 | 720502 | 222 | 16 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1524 |
| 1153 | HOWELLS PD | 101280 | 420122 | 725936 | 341 | 7 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1524 |
| 1154 | HOLBROOK PD | 111280 | 414033 | 722230 | 159 | 29 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1524 |
| 1155 | MILLERS PD | 101280 | 412857 | 713802 | 171 | 13 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1321 |
| 1156 | NORWICH PD | 91280 | 412311 | 721813 | 77 | 11 | 1 | 6 | 2 | 3 | 3 | 4.3 | 1321 |
| 1157 | POTTERS PD | 111280 | 420000 | 720304 | 219 | 7 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1524 |
| 1158 | SPRING PD | 101280 | 415529 | 724851 | 61 | 3 | 1 | 6 | 2 | 4 | 2 | 4.3 | 1524 |
| 1159 | UNCAS PD | 91280 | 412226 | 721852 | 25 | 28 | 1 | 5 | 1 | 4 | 3 | 4.3 | 1321 |
| 1160 | WHITMAN'S PD | 121280 | 415848 | 714811 | 159 | 10 | 1 | 6 | 2 | 3 | 2 | 4.3 | 1524 |
| 1189 | BLACKLEDGE R. MOUTH | 81080 | 413610 | 722536 | 136 | 3 | 2 | 4 | 2 | 3 | 2 | 4.3 | 1524 |
| 1190 | DICKINSON CRK. MOUTH | 81080 | 413337 | 722652 | 55 | 5 | 2 | 4 | 2 | 3 | 2 | 4.3 | 1524 |

| WATER CODE | DEPTH (M) | TEMP (C) | PH | PH | ALK (F.C.P) (UEQ/L) | ALK (F.C.P) (UEQ/L) | ALK (I.P) (UEQ/L) | ALK (I.P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1039 | 0 | 8 | 6.40 | 6.45 | 278 | 286 | 251 | 255 | 69 | 65 | 20 | 20 |
| 1096 | 0 | 15 | 6.75 | 6.85 | 237 | 241 | 212 | 210 | 59 | 56 | 10 | 10 |
| 1098 | 0 | 10 | 6.85 | 6.75 | 211 | 206 | 184 | 182 | 61 | 59 | 10 | 10 |
| 1099 | 0 | . | 6.80 | 6.75 | 278 | 281 | 251 | 250 | 105 | 110 | 10 | 10 |
| 1100 | 0 | 10 | 6.85 | 6.85 | 226 | 229 | 197 | 197 | 55 | 55 | 10 | 10 |
| 1101 | 0 | 15 | 6.50 | 6.50 | 118 | 125 | 90 | 93 | 32 | 31 | 20 | 20 |
| 1101 | 6 | 14 | 6.55 | 6.55 | 126 | 118 | 101 | 88 | 33 | 31 | 30 | 20 |
| 1102 | 0 | 14 | 6.60 | 6.55 | 120 | 120 | 93 | 90 | 36 | 33 | 90 | 100 |
| 1102 | 1 | 13 | 6.60 | 6.55 | 120 | 125 | 91 | 91 | 35 | 33 | 90 | 100 |
| 1147 | 0 | 4 | 6.15 | 6.33 | 78 | 91 | 56 | 61 | 41 | 39 | 40 | 50 |
| 1148 | 0 | 4 | 6.55 | 6.72 | 151 | 153 | 125 | 118 | 59 | 69 | 30 | 30 |
| 1148 | 1 | 3 | 6.55 | 6.69 | 148 | 155 | 122 | 121 | 61 | 59 | 30 | 30 |
| 1149 | 0 | 2 | 6.50 | 6.51 | 125 | 126 | 99 | 99 | 113 | 98 | 30 | 20 |
| 1149 | 3 | 3 | 6.35 | 6.33 | 128 | 133 | 102 | 106 | 30 | 29 | 30 | 30 |
| 1150 | 0 | 3 | 5.95 | 6.10 | 85 | 106 | 58 | 76 | 60 | 36 | 40 | 40 |
| 1151 | 0 | . | 4.55 | 4.65 | 3 | 9 | -22 | -19 | 57 | 56 | 10 | 10 |
| 1152 | 0 | 2 | 6.25 | 6.49 | 119 | 137 | 96 | 98 | 60 | 36 | 20 | 60 |
| 1153 | 0 | 2 | 5.45 | 5.52 | 41 | 45 | 13 | 20 | 29 | 31 | 30 | 30 |
| 1153 | 1 | 4 | 5.60 | 5.65 | 58 | 61 | 31 | 32 | 40 | 42 | 60 | 60 |
| 1154 | 0 | 2 | 6.30 | 6.86 | 259 | 269 | 240 | 237 | 88 | 82 | 60 | 30 |
| 1154 | 1 | 1 | 6.70 | 7.00 | 255 | 277 | 229 | 231 | 85 | 80 | 60 | 50 |
| 1155 | 0 | 3 | 5.55 | 5.58 | 26 | 35 | 6 | 7 | 30 | 29 | 30 | 10 |
| 1155 | 3 | 4 | 5.15 | 5.26 | 30 | 31 | -3 | 1 | 30 | 30 | 20 | 10 |
| 1156 | 0 | 5 | 6.55 | 6.97 | 244 | 263 | 219 | 215 | 52 | 50 | 30 | 30 |
| 1156 | 9 | 9 | 6.55 | 6.98 | 244 | 238 | 218 | 211 | 52 | 51 | 30 | 30 |
| 1157 | 0 | 3 | 6.00 | 6.28 | 78 | 101 | 56 | 63 | 50 | 37 | 40 | 40 |
| 1158 | 0 | 6 | 7.05 | 7.14 | 404 | 411 | 375 | 383 | 85 | 96 | 10 | 10 |
| 1159 | 0 | 4 | 6.75 | 6.89 | 151 | 157 | 124 | 124 | 42 | 52 | 10 | 10 |
| 1159 | 7 | 4 | 6.75 | 6.85 | 146 | 159 | 120 | 126 | 41 | 52 | 10 | 0 |
| 1160 | 0 | 2 | 4.95 | 5.08 | 21 | 29 | -5 | -5 | 44 | 46 | 40 | 50 |
| 1189 | 0 | 14 | 6.75 | 6.85 | 272 | 272 | 248 | 248 | 99 | 97 | 10 | 10 |
| 1190 | 0 | 11 | 6.65 | 6.85 | 201 | 202 | 176 | 176 | 93 | 93 | 10 | 10 |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | TOC (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1039 | 4.0 | 4.5 | 9.6 | 10.8 | 16 | 5.99 | 1.56 | 1.24 | 0.023 | 3.74 | 2.5 |
| 1096 | 7.9 | 7.9 | 7.4 | 7.2 | 35 | 3.16 | 1.34 | 1.56 | 0.015 | 4.54 | 1.9 |
| 1098 | 2.4 | 2.6 | 6.4 | 6.1 | 67 | 2.57 | 1.51 | 0.92 | 0.032 | 3.01 | 1.9 |
| 1099 | 14.7 | 14.9 | 13.4 | 13.2 | 19 | 6.75 | 2.60 | 1.92 | 0.028 | 9.61 | 1.9 |
| 1100 | 9.0 | 9.0 | 6.4 | 5.9 | 14 | 3.91 | 1.64 | 1.24 | 0.013 | 4.49 | 1.9 |
| 1101 | 0.9 | 1.2 | 7.4 | 7.2 | 10 | 2.53 | 0.72 | 0.88 | 0.065 | 1.22 | 2.5 |
| 1101 | 1.5 | 1.6 | 7.2 | 6.8 | 12 | 2.56 | 0.68 | 0.78 | 0.069 | 1.21 | 2.9 |
| 1102 | 3.5 | 3.6 | 6.7 | 6.2 | 146 | 2.19 | 1.04 | 0.56 | 0.044 | 1.97 | 7.1 |
| 1102 | 4.1 | 3.6 | 6.2 | 5.8 | 131 | 2.28 | 1.03 | 0.97 | 0.065 | 1.95 | 7.1 |
| 1147 | 7.1 | 7.1 | 4.8 | 4.8 | 59 | 1.83 | 0.63 | 1.26 | 0.026 | 3.32 | 6.1 |
| 1148 | 7.4 | 7.4 | 8.5 | 8.4 | 70 | 4.36 | 0.58 | 1.10 | 0.034 | 4.53 | 2.9 |
| 1148 | 5.2 | 7.7 | 6.5 | 6.7 | 91 | 4.43 | 0.58 | 1.13 | 0.040 | 4.55 | 2.9 |
| 1149 | 18.8 | 18.8 | 6.7 | 6.7 | 47 | 4.83 | 1.30 | 1.35 | 0.033 | 9.48 | 2.9 |
| 1149 | 18.9 | 18.4 | 6.9 | 7.0 | 33 | 4.87 | 1.31 | 1.38 | 0.032 | 9.52 | 2.9 |
| 1150 | 3.6 | 3.7 | 7.0 | 6.7 | 79 | 2.41 | 1.03 | 0.85 | 0.032 | 2.53 | 3.9 |
| 1151 | 8.1 | 8.6 | 7.0 | 7.2 | 334 | 2.01 | 0.29 | 0.82 | 0.023 | 4.82 | 1.9 |
| 1152 | 3.7 | 3.7 | 6.1 | 5.7 | 74 | 2.92 | 0.72 | 1.07 | 0.038 | 2.32 | 5.3 |
| 1153 | 1.1 | 1.5 | 11.0 | 12.0 | 109 | 2.41 | 0.57 | 0.72 | 0.067 | 1.39 | 3.2 |
| 1153 | 2.3 | 2.2 | 10.9 | 10.2 | 131 | 3.31 | 0.74 | 0.98 | 0.089 | 1.42 | 5.0 |
| 1154 | 7.5 | 7.7 | 15.1 | 15.5 | 21 | 6.06 | 2.10 | 2.09 | 0.039 | 4.16 | 3.5 |
| 1154 | 7.9 | 8.2 | 12.9 | 12.6 | 161 | 6.24 | 2.06 | 2.08 | 0.058 | 4.16 | 4.1 |
| 1155 | 2.6 | 2.5 | 8.4 | 8.3 | 56 | 1.13 | 0.93 | 0.70 | 0.034 | 2.15 | 2.2 |
| 1155 | 3.2 | 3.4 | 8.9 | 7.9 | 79 | 1.17 | 1.13 | 0.69 | 0.032 | 2.77 | 2.2 |
| 1156 | 4.3 | 4.2 | 8.8 | 8.4 | 62 | 4.12 | 0.79 | 1.65 | 0.032 | 2.87 | 3.2 |
| 1156 | 4.2 | 4.0 | 8.6 | 8.6 | 93 | 4.15 | 0.78 | 1.66 | 0.032 | 2.86 | 3.2 |
| 1157 | 3.1 | 3.0 | 10.5 | 10.3 | 55 | 2.95 | 1.05 | 0.55 | 0.033 | 2.30 | 3.8 |
| 1158 | 7.8 | 7.9 | 11.2 | 10.7 | 12 | 9.44 | 0.66 | 1.40 | 0.017 | 3.71 | 1.9 |
| 1159 | 3.6 | 3.6 | 8.6 | 8.7 | 0 | 2.94 | 0.85 | 1.10 | 0.037 | 2.98 | 1.9 |
| 1159 | 3.8 | 4.0 | 8.8 | 8.5 | 7 | 2.91 | 0.85 | 1.08 | 0.031 | 2.92 | 1.6 |
| 1160 | 5.8 | 5.8 | 8.2 | 7.9 | 367 | 1.70 | 0.43 | 0.49 | 0.083 | 3.34 | 3.8 |
| 1189 | 14.4 | 14.6 | 11.8 | 11.8 | 38 | 6.37 | 2.33 | 1.73 | 0.014 | 8.36 | 1.9 |
| 1190 | 15.2 | 15.2 | 10.9 | 10.6 | 33 | 4.85 | 1.92 | 0.32 | 0.032 | 8.87 | 1.9 |

## USFWS ACID RAIN SENSITIVITY PROJECT
## STATE OF MAINE

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | HYDRO. | BED ROCK | SOIL TYPE | DISTR. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1012 | LITTLE SWIFT RIVER P | 300780 | 445152 | 703542 | 735 | 6 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1118 |
| 1013 | SOUTH PD | 310780 | 445252 | 703251 | 662 | 4 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1118 |
| 1025 | LITTLE LONG PD | 120880 | 443806 | 680441 | 63 | 72 | 1 | 5 | 1 | 4 | 1 | 4.4 | 1727 |
| 1026 | TILDEN PD | 120880 | 443750 | 680430 | 63 | 15 | 1 | 6 | 1 | 4 | 1 | 4.4 | 1727 |
| 1027 | MUD PD | 140880 | 443750 | 680538 | 110 | 1 | 1 | 6 | 1 | 4 | 1 | 4.4 | 1727 |
| 1028 | SALMON PD | 140880 | 443750 | 680441 | 94 | 4 | 1 | 6 | 1 | 4 | 1 | 4.4 | 1727 |
| 1029 | DAY MOUNTAIN PD | 190880 | 444633 | 701500 | 407 | 5 | 1 | 6 | 2 | 4 | 2 | 4.3 | 1118 |
| 1030 | SPENCER PD | 180980 | 444911 | 704047 | 663 | 6 | 1 | 6 | 2 | 4 | 2 | 4.3 | 1118 |
| 1067 | ANDERSON PD | 170980 | 443842 | 680351 | 66 | 5 | 1 | 6 | 1 | 3 | 1 | 4.4 | 1524 |
| 1068 | UNNAMED PD | 170980 | 443842 | 680671 | 76 | 7 | 1 | 5 | 1 | 4 | 3 | 4.4 | 1524 |
| 1108 | PEEP PD | 211080 | 445436 | 675339 | 78 | 13 | 1 | 6 | 1 | 4 | 2 | 4.4 | 1524 |
| 1109 | PRETTY PD | 211080 | 444941 | 675425 | 82 | 11 | 1 | 6 | 3 | 3 | 2 | 4.4 | 1524 |
| 1110 | SALMON PD | 211080 | 445502 | 675144 | 76 | 4 | 1 | 6 | 1 | 3 | 2 | 4.4 | 1524 |
| 1162 | IRONBOUND PD | 40381 | 454604 | 700523 | 413 | 16 | 1 | 6 | 2 | 5 | 1 | 4.3 | 914 |
| 1163 | FOLEY PD | 40381 | 455605 | 700316 | 450 | 50 | 1 | 5 | 2 | 5 | 2 | 4.3 | 914 |
| 1164 | CRANBERRY PD | 40381 | 455133 | 692808 | 323 | 18 | 1 | 6 | 3 | 5 | 2 | 4.2 | 914 |
| 1165 | UPPER FIRST ST. JOHN | 40381 | 460208 | 695907 | 566 | 12 | 1 | 6 | 2 | 5 | 1 | 4.2 | 914 |
| 1166 | ALLAGASH PD | 40381 | 462527 | 694011 | 409 | 42 | 1 | 6 | 2 | 5 | 2 | 4.2 | 914 |
| 1167 | MOUNTAIN PD | 40381 | 461845 | 693609 | 346 | 8 | 1 | 6 | 2 | 5 | 1 | 4.2 | 914 |
| 1168 | JONES PD | 40381 | 454837 | 701241 | 472 | 53 | 1 | 5 | 2 | 5 | 2 | 4.2 | 914 |
| 1169 | CORNER PD | 40381 | 462350 | 694350 | 487 | 40 | 1 | 6 | 2 | 5 | 2 | 4.2 | 914 |
| 1170 | TURNER PD | 40381 | 461636 | 694730 | 409 | 42 | 1 | 5 | 2 | 5 | 2 | 4.2 | 914 |
| 1171 | FERGUSON PD | 40381 | 465158 | 684155 | 252 | 21 | 1 | 5 | 3 | 5 | 2 | 4.3 | 914 |
| 1172 | AUSTIN PD | 40381 | 460313 | 695655 | 366 | 17 | 1 | 6 | 2 | 5 | 1 | 4.2 | 914 |
| 1173 | UGH PD | 40381 | 464411 | 693314 | 396 | 32 | 1 | 6 | 2 | 5 | 1 | 4.2 | 914 |
| 1174 | 4TH PELLETIER BRK. L | 40381 | 470144 | 685328 | 398 | 20 | 1 | 5 | 2 | 5 | 2 | 4.2 | 914 |
| 1175 | B LAKE | 40381 | 461203 | 680230 | 220 | 27 | 1 | 6 | 3 | 4 | 2 | 4.3 | 1118 |
| 1176 | MCPHERSON PD | 40381 | 463302 | 685907 | 252 | 31 | 1 | 5 | 2 | 5 | 2 | 4.2 | 914 |
| 1177 | PLUFFER PD | 40381 | 462230 | 690558 | 347 | 16 | 1 | 5 | 3 | 5 | 1 | 4.2 | 1118 |
| 1178 | 2ND CURRIER PD | 40381 | 462502 | 690532 | 386 | 11 | 1 | 6 | 3 | 5 | 1 | 4.2 | 914 |
| 1179 | UPPER HUDSON PD | 40381 | 463433 | 690144 | 427 | 13 | 1 | 6 | 2 | 5 | 1 | 4.2 | 914 |
| 1180 | CUNLIFFE PD | 40381 | 464644 | 694804 | 346 | 25 | 1 | 6 | 2 | 5 | 2 | 4.2 | 914 |
| 1181 | WEST LAKE | 40381 | 462414 | 680718 | 283 | 9 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1118 |
| 1197 | CAIN PD | 10681 | 442930 | 685802 | 69 | 13 | 1 | 6 | 2 | 4 | 2 | 4.4 | 1524 |
| 1198 | COLBY PD | 10681 | 442128 | 692254 | 129 | 11 | 1 | 6 | 2 | 4 | 2 | 4.4 | 1321 |
| 1199 | LITTLE PD | 10681 | 443425 | 681019 | 74 | 12 | 1 | 6 | 1 | 4 | 2 | 4.4 | 1727 |
| 1200 | NEWBERT PD | 10681 | 442005 | 691630 | 86 | 28 | 1 | 6 | 2 | 4 | 2 | 4.4 | 1524 |
| 1201 | HALFMILE PD | 170581 | 445350 | 691500 | 176 | 44 | 1 | 6 | 2 | 4 | 2 | 4.4 | 1524 |
| 1202 | ROUND PD | 280481 | 433056 | 703526 | 70 | 2 | 1 | 6 | 1 | 3 | 4 | 4.3 | 1321 |
| 1203 | SUNSET PD | 40581 | 452254 | 692508 | 406 | 3 | 1 | 6 | 2 | 4 | 2 | 4.3 | 1321 |
| 1204 | MIDDAY PD | 40581 | 452253 | 692507 | 401 | 5 | 1 | 5 | 2 | 4 | 2 | 4.3 | 1321 |
| 1212 | ANDERSON PD | 240779 | 442116 | 693837 | 76 | 4 | 1 | 6 | 1 | 5 | 1 | 4.3 | 1321 |
| 1213 | BEAVER PD | 230978 | 444828 | 704115 | 602 | 8 | 1 | 5 | 2 | 4 | 4 | 4.3 | 1118 |
| 1214 | BUBBLE PD | 100978 | 441957 | 681415 | 137 | 13 | 1 | 6 | 1 | 3 | 1 | 4.5 | 1524 |
| 1215 | DEBEC PD | 120978 | 444739 | 682719 | 125 | 13 | 1 | 5 | 1 | 4 | 3 | 4.4 | 1524 |
| 1216 | DENNY PD | 210879 | 465623 | 685218 | 366 | 10 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1016 |
| 1217 | FITTS PD | 190978 | 444547 | 683126 | 98 | 43 | 1 | 5 | 1 | 4 | 1 | 4.3 | 1321 |
| 1218 | HEALD PD | 220978 | 454332 | 701425 | 457 | 75 | 1 | 5 | 2 | 5 | 1 | 4.2 | 1118 |
| 1219 | HORSESHOE PD | 220978 | 453022 | 692446 | 448 | 65 | 1 | 5 | 2 | 4 | 1 | 4.3 | 1118 |
| 1220 | LINCOLN PD | 230978 | 450419 | 705655 | 518 | 138 | 1 | 5 | 1 | 4 | 1 | 4.3 | 1016 |
| 1221 | LITTLE TUNK PD | 260779 | 443508 | 680707 | 71 | 57 | 1 | 5 | 1 | 4 | 1 | 4.5 | 1524 |
| 1222 | SANDY PD | 220978 | 445419 | 695523 | 127 | 43 | 1 | 5 | 2 | 3 | 1 | 4.3 | 1321 |
| 1223 | SIDE PISTOL LAKE | 30779 | 451111 | 681009 | 130 | 60 | 1 | 5 | 1 | 4 | 1 | 4.4 | 1524 |
| 1224 | TRAFTON PD | 80879 | 435049 | 705337 | 152 | 23 | 1 | 6 | 2 | 3 | 3 | 4.3 | 1219 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1225 | TROUT PD | 60879 | 441419 | 704908 | 242 | 28 | 1 | 5 | 1 | 4 | 1 | 4.3 | 1118 |
| 1226 | LEDGE PD | 200779 | 445450 | 703200 | 911 | 3 | 1 | 6 | 1 | 4 | 1 | 4.3 | 1118 |
| 1227 | EAST CHAIRBACK PD | 160780 | 452747 | 691643 | 466 | 18 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1321 |
| 1228 | MOUNTAIN PD-COBURN | 290580 | 452840 | 700651 | 871 | 2 | 1 | 6 | 2 | 4 | 1 | 4.2 | 1118 |
| 1229 | SPECK PD | 60979 | 443346 | 705821 | 999 | 4 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1016 |
| 1230 | TUMBLEDOWN PD | 270778 | 444458 | 703240 | 813 | 4 | 1 | 5 | 2 | 4 | 1 | 4.3 | 1118 |
| 1231 | KLONDIKE PD | 141078 | 455539 | 685710 | 999 | 5 | 1 | 5 | 1 | 5 | 1 | 4.3 | 1321 |
| 1232 | THE HORNS PD | 120779 | 450840 | 702014 | 948 | 5 | 1 | 6 | 2 | 4 | 1 | 4.3 | 1118 |
| 1233 | MOUNTAIN PD-RANGELEY | 160879 | 445340 | 703849 | 733 | 17 | 1 | 5 | 2 | 4 | 1 | 4.3 | 1118 |

| WATER CODE | DEPTH (M) | TEMP ( C) | PH | PH | ALK (F.E.P) (UEQ/L) | ALK (F.E.P) (UEQ/L) | ALK (I.P) (UEQ/L) | ALK (I.P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1012 | 0 | 21 | 5.55 | . | 38 | . | 6 | . | 18 | . | 20 | . |
| 1012 | 4 | 18 | 5.55 | . | 40 | . | 10 | . | 15 | . | 30 | . |
| 1013 | 0 | 20 | 5.60 | . | 36 | . | 4 | . | 17 | . | 10 | . |
| 1013 | 2 | 19 | 5.60 | . | 38 | . | 4 | . | 15 | . | 10 | . |
| 1025 | 0 | . | 6.05 | 5.95 | 43 | 47 | 7 | 17 | 23 | 22 | 0 | 0 |
| 1025 | 15 | . | 5.70 | 5.75 | 46 | 43 | 15 | 10 | 24 | 23 | 0 | 0 |
| 1026 | 0 | 23 | 6.55 | 6.60 | 86 | 72 | 44 | 37 | 24 | 22 | 10 | 10 |
| 1026 | 9 | 15 | 5.75 | 5.80 | 91 | 86 | 51 | 48 | 26 | 26 | 30 | 30 |
| 1027 | 0 | 23 | 4.70 | 4.65 | 16 | 14 | -22 | -22 | 33 | 33 | 0 | 0 |
| 1027 | 11 | 13 | 4.10 | 4.05 | 0 | 0 | -58 | -66 | 47 | 46 | 20 | 20 |
| 1028 | 0 | . | 6.75 | 6.75 | 91 | 91 | 47 | 45 | 21 | 23 | 20 | 20 |
| 1028 | 8 | 15 | 5.85 | 5.80 | 111 | 111 | 80 | 74 | 20 | 21 | 10 | 10 |
| 1029 | 0 | . | 7.20 | 7.20 | 383 | 366 | 342 | 391 | 44 | 43 | 40 | 40 |
| 1029 | 6 | . | 6.40 | 6.45 | 409 | 398 | 374 | 367 | 48 | 48 | 40 | 40 |
| 1030 | 0 | 21 | 6.05 | 6.05 | 50 | 54 | 13 | 15 | 16 | 16 | 0 | 0 |
| 1030 | 7 | 21 | 6.10 | 6.10 | 54 | 51 | 16 | 19 | 16 | 16 | 0 | 0 |
| 1067 | 0 | . | 6.15 | 6.13 | 46 | 53 | 19 | 20 | 18 | 18 | 10 | 10 |
| 1067 | 5 | . | 6.08 | 6.10 | 50 | 43 | 22 | 18 | 16 | 16 | 10 | 10 |
| 1068 | 0 | . | 5.89 | 5.80 | 51 | 40 | 20 | 15 | 21 | 21 | 120 | 120 |
| 1069 | 3 | . | 5.80 | 5.75 | 46 | 52 | 18 | 17 | 20 | 20 | 110 | 110 |
| 1108 | 0 | 9 | 5.75 | 5.73 | 36 | 41 | 11 | 12 | 16 | 16 | 10 | 10 |
| 1108 | 5 | 9 | 5.50 | 5.70 | 37 | 37 | 12 | 12 | 13 | 13 | 0 | 0 |
| 1109 | 0 | 9 | 4.80 | 4.92 | 12 | 29 | -16 | -15 | 23 | 15 | 0 | 10 |
| 1109 | 3 | 9 | 4.80 | 4.92 | 17 | 28 | -13 | -14 | 18 | 16 | 0 | 0 |
| 1110 | 0 | 10 | 4.78 | 4.70 | 22 | 13 | -18 | -15 | 14 | 14 | 20 | 20 |
| 1110 | 4 | 9 | 4.75 | 4.75 | 14 | 14 | -13 | -16 | 16 | 16 | 20 | 20 |
| 1162 | 0 | 2 | 6.65 | 6.62 | 460 | 487 | 433 | 452 | 57 | 62 | 10 | 10 |
| 1162 | 2 | 4 | 6.55 | 6.50 | 516 | 547 | 489 | 519 | 61 | 70 | 10 | 10 |
| 1163 | 0 | 1 | 6.55 | 6.50 | 186 | 199 | 162 | 167 | 37 | 35 | 30 | 20 |
| 1163 | 10 | 4 | 6.70 | 6.75 | 505 | 513 | 474 | 478 | 62 | 60 | 10 | 10 |
| 1164 | 0 | 1 | 6.85 | 6.62 | 360 | 360 | 329 | 337 | 47 | 47 | 40 | 30 |
| 1164 | 1 | 3 | 6.90 | 6.96 | 1160 | 1163 | 1133 | 1130 | 120 | 120 | 30 | 30 |
| 1165 | 0 | 1 | 6.05 | 6.33 | 113 | 126 | 84 | 91 | 33 | 36 | 20 | 30 |
| 1165 | 2 | 2 | 6.15 | 6.16 | 132 | 131 | 108 | 105 | 33 | 36 | 20 | 30 |
| 1166 | 0 | 0 | 5.65 | 5.78 | 145 | 69 | 115 | 34 | 22 | 23 | 40 | 40 |
| 1166 | 2 | 1 | 5.95 | 6.22 | 157 | 151 | 118 | 181 | 34 | 35 | 40 | 40 |
| 1167 | 0 | 0 | 6.60 | 5.95 | 221 | 196 | 154 | 168 | 34 | 33 | 20 | 20 |
| 1168 | 0 | 1 | 6.55 | 6.47 | 226 | 225 | 195 | 202 | 35 | 35 | 20 | 20 |
| 1168 | 4 | 4 | 6.65 | 6.63 | 441 | 452 | 425 | 430 | 52 | 51 | 20 | 20 |
| 1169 | 0 | 0 | 6.45 | 6.42 | 276 | 264 | 236 | 230 | 40 | 45 | 30 | 40 |
| 1169 | 2 | 1 | 6.45 | 6.48 | 519 | 519 | 475 | 477 | 66 | 74 | 50 | 70 |
| 1170 | 0 | 1 | 6.15 | 6.37 | 125 | 137 | 97 | 97 | 33 | 36 | 40 | 60 |
| 1170 | 9 | 3 | 6.30 | 6.46 | 186 | 212 | 160 | 168 | 36 | 41 | 50 | 70 |
| 1171 | 0 | 1 | 7.26 | 7.10 | 977 | 1007 | 992 | 944 | 110 | 125 | 20 | 30 |
| 1171 | 2 | 3 | 7.45 | 7.15 | 1601 | 1537 | 1563 | 1524 | 165 | 180 | 20 | 30 |
| 1172 | 0 | 1 | 6.45 | 6.40 | 307 | 278 | 271 | 320 | 43 | 42 | 30 | 20 |
| 1172 | 2 | 4 | 6.88 | 6.70 | 1019 | 1075 | 987 | 1036 | 100 | 100 | 20 | 20 |
| 1173 | 0 | 1 | 6.25 | 6.43 | 267 | 254 | 224 | 230 | 38 | 35 | 40 | 30 |
| 1173 | 1 | 1 | 6.45 | 6.50 | 418 | 394 | 393 | 376 | 55 | 51 | 30 | 30 |
| 1174 | 0 | 0 | 6.60 | 7.22 | 777 | 766 | 760 | 741 | 85 | 84 | 20 | 20 |
| 1174 | 1 | 2 | 7.05 | 7.20 | 1467 | 1461 | 1441 | 1430 | 140 | 140 | 20 | 20 |
| 1175 | 0 | 1 | 6.55 | 6.35 | 215 | 201 | 176 | 172 | 32 | 33 | 20 | 20 |
| 1175 | 2 | 3 | 6.59 | 6.55 | 476 | 470 | 454 | 428 | 52 | 52 | 20 | 20 |
| 1176 | 0 | 1 | 6.30 | 6.52 | 170 | 162 | 133 | 128 | 36 | 36 | 20 | 20 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1176 | 5 | 1 | 6.35 | 6.55 | 174 | 173 | 141 | 138 | 37 | 36 | 20 | 20 |
| 1177 | 0 | 0 | 6.55 | 6.73 | 197 | 208 | 170 | 173 | 46 | 52 | 20 | 30 |
| 1177 | 1 | 1 | 6.60 | 6.75 | 263 | 242 | 235 | 207 | 50 | 54 | 20 | 30 |
| 1178 | 0 | 1 | 6.15 | 6.45 | 209 | 197 | 181 | 172 | 34 | 60 | 30 | 40 |
| 1178 | 2 | 1 | 6.59 | 6.65 | 615 | 580 | 587 | 560 | 58 | 68 | 70 | 100 |
| 1179 | 0 | 0 | 6.45 | 6.92 | 232 | 270 | 192 | 190 | 38 | 46 | 10 | 20 |
| 1179 | 8 | 1 | 6.80 | 6.93 | 267 | 255 | 241 | 221 | 39 | 46 | 10 | 20 |
| 1180 | 0 | 0 | 6.75 | 6.70 | 267 | 267 | 244 | 246 | 41 | 50 | 40 | 40 |
| 1180 | 3 | 1 | 6.75 | 6.80 | 395 | 406 | 375 | 377 | 56 | 62 | 30 | 40 |
| 1181 | 0 | 1 | 6.35 | 6.30 | 197 | 197 | 179 | 172 | 28 | 32 | 30 | 50 |
| 1181 | 1 | 1 | 7.12 | 7.15 | 777 | 777 | 748 | 742 | 85 | 97 | 20 | 30 |
| 1197 | 3 | 8 | 6.65 | 6.60 | 188 | . | 154 | . | 38 | 40 | 10 | 10 |
| 1198 | 2 | 9 | 5.40 | 5.56 | 45 | . | 17 | . | 26 | 28 | 60 | 60 |
| 1199 | 0 | 18 | 5.75 | 5.80 | 50 | 47 | 24 | 26 | 29 | 27 | 10 | 10 |
| 1200 | 2 | 7 | 4.55 | 4.55 | 5 | . | -30 | . | 32 | 34 | 100 | 100 |
| 1201 | 0 | 11 | 6.50 | 6.55 | 111 | . | 82 | . | 24 | 24 | 0 | 0 |
| 1201 | 17 | 10 | . | . | . | . | . | . | . | . | . | . |
| 1202 | 0 | 12 | 6.25 | . | 55 | . | 33 | . | 18 | . | 10 | . |
| 1202 | 4 | 11 | 5.55 | . | 47 | . | 20 | . | 17 | . | 10 | . |
| 1203 | 0 | 8 | 5.15 | . | 32 | . | 0 | . | 24 | . | 0 | . |
| 1204 | 0 | 8 | 5.85 | . | 43 | . | 25 | . | 22 | . | 0 | 0 |
| 1212 | 1 | . | 6.62 | . | 84 | . | . | . | . | . | 45 | . |
| 1213 | 1 | . | 6.30 | . | 56 | . | . | . | . | . | 0 | . |
| 1214 | 1 | . | 6.40 | . | 66 | . | . | . | . | . | 0 | . |
| 1215 | 1 | . | 6.85 | . | 316 | . | . | . | . | . | 15 | . |
| 1216 | 1 | . | 6.93 | . | 360 | . | . | . | . | . | 10 | . |
| 1217 | 1 | . | 5.97 | . | 56 | . | . | . | . | . | 0 | . |
| 1218 | 1 | . | 6.65 | . | 116 | . | . | . | . | . | 8 | . |
| 1219 | 1 | . | 6.70 | . | 170 | . | . | . | . | . | 0 | . |
| 1220 | 1 | . | 6.55 | . | 50 | . | . | . | . | . | 0 | . |
| 1221 | 1 | . | 6.13 | . | 20 | . | . | . | . | . | 6 | . |
| 1222 | 1 | . | 6.20 | . | 36 | . | . | . | . | . | 6 | . |
| 1223 | 1 | . | 6.41 | . | 90 | . | . | . | . | . | 5 | . |
| 1224 | 1 | . | 6.88 | . | 192 | . | . | . | . | . | 10 | . |
| 1225 | 1 | . | 6.40 | . | 80 | . | . | . | . | . | . | . |
| 1226 | 0 | 21 | 4.50 | . | . | . | . | . | . | . | . | . |
| 1226 | 6 | 6 | 4.50 | . | . | . | . | . | . | . | . | . |
| 1227 | 1 | 22 | 5.15 | . | 27 | . | -7 | . | 17 | . | 0 | . |
| 1227 | 9 | 20 | 5.20 | . | 29 | . | -5 | . | 19 | . | 0 | . |
| 1228 | 0 | 11 | 6.60 | . | 75 | . | 43 | . | 18 | . | 20 | . |
| 1228 | 3 | 11 | 6.65 | . | 75 | . | 47 | . | 19 | . | 20 | . |
| 1229 | 0 | 18 | 5.10 | . | 33 | . | -6 | . | . | . | . | . |
| 1229 | 8 | 13 | 5.05 | . | 50 | . | 12 | . | . | . | . | . |
| 1230 | 0 | . | 4.80 | . | . | . | 0 | . | 18 | . | 5 | . |
| 1231 | 1 | . | 5.50 | . | . | . | 40 | . | 20 | . | 8 | . |
| 1231 | 8 | . | 5.80 | . | . | . | 40 | . | 19 | . | 7 | . |
| 1232 | 6 | . | 5.60 | . | . | . | -4 | . | . | . | 15 | . |
| 1233 | 0 | 14 | 5.75 | . | 50 | . | 13 | . | . | . | . | . |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | TOC (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1012 | 1.1 | 1.1 | 5.3 | 4.8 | 117 | 1.40 | 0.35 | 0.28 | 0.025 | 0.74 | 2.5 |
| 1012 | 0.6 | 0.8 | 4.6 | 4.5 | 194 | 1.43 | 0.30 | 0.27 | 0.029 | 0.61 | 3.2 |
| 1013 | 0.1 | 0.0 | 4.0 | 4.1 | 12 | 1.20 | 0.15 | 0.26 | 0.031 | 0.55 | 1.9 |
| 1013 | 0.2 | 0.7 | 4.1 | 4.1 | 136 | 1.23 | 0.14 | 0.26 | 0.033 | 0.52 | 1.9 |
| 1025 | 2.7 | 2.8 | 3.0 | 3.2 | 66 | 0.81 | 0.38 | 0.33 | 0.076 | 2.17 | 1.3 |
| 1025 | 3.4 | 3.3 | 2.8 | 2.6 | 12 | 0.86 | 0.35 | 0.34 | 0.056 | 2.09 | 1.3 |
| 1026 | 2.1 | 2.7 | 2.8 | 2.5 | 0 | 1.03 | 0.33 | 0.34 | 0.013 | 2.17 | 1.9 |
| 1026 | 3.3 | 3.2 | 2.4 | 2.2 | 0 | 1.38 | 0.34 | 0.40 | 0.124 | 2.14 | 3.2 |
| 1027 | 3.7 | 3.8 | 3.8 | 3.6 | 240 | 0.75 | 0.34 | 0.33 | 0.026 | 2.38 | 1.3 |
| 1027 | 4.2 | 4.4 | 3.5 | 3.8 | 406 | 0.66 | 0.40 | 0.32 | 0.029 | 2.19 | 2.5 |
| 1028 | 3.2 | 2.9 | 2.0 | 2.3 | 2 | 1.23 | 0.61 | 0.38 | 0.110 | 2.23 | 2.5 |
| 1028 | 2.8 | 2.6 | 1.8 | 2.0 | 51 | 1.54 | 0.52 | 0.43 | 0.071 | 1.96 | 1.9 |
| 1029 | 1.1 | 1.4 | 3.0 | 2.9 | 43 | 6.74 | 0.44 | 0.46 | 0.023 | 1.07 | 3.8 |
| 1029 | 0.5 | 0.4 | 3.4 | 3.2 | 55 | 7.00 | 0.71 | 0.41 | 0.310 | 0.93 | 3.8 |
| 1030 | 0.7 | 0.7 | 3.5 | 3.6 | 54 | 1.15 | 0.46 | 0.42 | 0.053 | 0.67 | 1.3 |
| 1030 | 0.0 | 0.1 | 3.7 | 3.5 | 48 | 1.13 | 0.45 | 0.43 | 0.054 | 0.70 | 1.3 |
| 1067 | 2.1 | 1.9 | 4.5 | 4.1 | 0 | 0.70 | 0.36 | 0.30 | 0.020 | 1.83 | 1.9 |
| 1067 | 2.2 | 2.0 | 4.1 | 3.8 | 13 | 0.77 | 0.42 | 0.29 | 0.024 | 1.91 | 1.9 |
| 1068 | 3.1 | 3.0 | 3.8 | 3.4 | 89 | 0.88 | 0.26 | 0.41 | 0.039 | 2.22 | 8.7 |
| 1068 | 2.4 | 2.2 | 3.8 | 3.7 | 137 | 0.92 | 0.22 | 0.41 | 0.016 | 2.24 | 8.1 |
| 1108 | 2.1 | 1.7 | 3.4 | 3.5 | 23 | 0.50 | 0.39 | 0.20 | 0.012 | 1.47 | 1.9 |
| 1108 | 1.8 | 1.7 | 3.1 | 2.8 | 21 | 0.49 | 0.36 | 0.20 | 0.017 | 1.44 | 1.3 |
| 1109 | 1.2 | 1.1 | 3.5 | 3.7 | 108 | 0.33 | 0.20 | 0.18 | 0.020 | 1.08 | 1.6 |
| 1109 | 1.2 | 1.2 | 4.1 | 3.5 | 127 | 0.32 | 0.20 | 0.18 | 0.013 | 1.07 | 1.3 |
| 1110 | 3.7 | 3.6 | 3.5 | 3.6 | 40 | 0.36 | 0.15 | 0.16 | 0.017 | 1.02 | 2.5 |
| 1110 | 1.2 | 1.1 | 3.4 | 3.4 | 76 | 0.38 | 0.14 | 0.16 | 0.041 | 1.02 | 2.5 |
| 1162 | 0.5 | 0.7 | 6.6 | 7.2 | 28 | 8.23 | 0.31 | 1.04 | 0.032 | 1.04 | 1.9 |
| 1162 | 0.6 | 0.6 | 6.4 | 7.0 | 12 | 8.65 | 0.31 | 1.04 | 0.039 | 1.15 | 1.9 |
| 1163 | 0.1 | 0.2 | 6.9 | 6.5 | 71 | 4.58 | 0.21 | 1.15 | 0.010 | 0.63 | 2.9 |
| 1163 | 0.0 | 0.0 | 6.7 | 6.7 | 39 | 8.54 | 0.21 | 1.88 | 0.010 | 1.04 | 1.9 |
| 1164 | 1.0 | 1.3 | 6.5 | 6.2 | 122 | 6.56 | 0.52 | 1.04 | 0.006 | 0.63 | 3.5 |
| 1164 | 0.6 | 0.6 | 8.1 | 7.8 | 50 | 26.15 | 0.31 | 1.35 | 0.005 | 0.83 | 3.2 |
| 1165 | 1.3 | 1.1 | 8.1 | 7.7 | 65 | 3.54 | 0.31 | 1.04 | 0.027 | 0.63 | 2.9 |
| 1165 | 1.2 | 1.3 | 6.0 | 6.2 | 58 | 6.46 | 0.31 | 1.77 | 0.100 | 0.83 | 2.9 |
| 1166 | 0.4 | 0.7 | 6.7 | 6.7 | 176 | 2.08 | 0.42 | 0.63 | 0.018 | 0.63 | 3.8 |
| 1166 | 0.3 | 0.4 | 6.7 | 7.2 | 121 | 3.65 | 0.42 | 0.83 | 0.015 | 0.73 | 3.8 |
| 1167 | 0.0 | 0.0 | 7.7 | 7.2 | 174 | 4.48 | 0.21 | 0.83 | 0.007 | 0.73 | 2.0 |
| 1168 | 0.0 | 0.1 | 6.6 | 6.7 | 75 | 4.58 | 0.31 | 0.94 | 0.018 | 0.73 | 2.5 |
| 1168 | 0.1 | 0.2 | 6.1 | 5.9 | 16 | 7.81 | 0.31 | 1.46 | 0.198 | 1.77 | 2.5 |
| 1169 | 0.8 | 1.4 | 7.3 | 7.3 | 43 | 5.63 | 0.31 | 1.04 | 0.036 | 0.73 | 3.5 |
| 1169 | 0.0 | 0.0 | 7.2 | 6.7 | 15 | 6.04 | 0.31 | 1.04 | 0.044 | 0.73 | 5.0 |
| 1170 | 0.2 | 0.3 | 8.3 | 8.6 | 110 | 3.65 | 0.31 | 1.04 | 0.020 | 0.83 | 4.4 |
| 1170 | 0.7 | 0.6 | 7.4 | 7.2 | 105 | 4.58 | 0.31 | 1.25 | 0.029 | 0.94 | 5.0 |
| 1171 | 0.7 | 0.8 | 11.4 | 11.0 | 74 | 21.47 | 0.21 | 1.25 | 0.010 | 1.25 | 2.9 |
| 1171 | 1.3 | 1.2 | 16.2 | 16.0 | 7 | 31.26 | 0.21 | 1.46 | 0.022 | 1.46 | 2.9 |
| 1172 | 0.9 | 1.0 | 6.4 | 6.5 | 87 | 5.31 | 0.31 | 1.56 | 0.021 | 0.73 | 2.9 |
| 1172 | 0.9 | 0.8 | 5.9 | 5.9 | 20 | 13.13 | 0.31 | 3.33 | 0.089 | 1.15 | 2.5 |
| 1173 | 0.8 | 1.0 | 6.2 | 6.0 | 5 | 6.98 | 0.42 | 0.63 | 0.042 | 0.73 | 3.5 |
| 1173 | 0.9 | 0.9 | 6.3 | 7.0 | 17 | 5.94 | 0.42 | 0.73 | 0.050 | 0.83 | 3.2 |
| 1174 | 1.0 | 1.1 | 6.1 | 5.9 | 20 | 15.21 | 0.21 | 1.25 | 0.010 | 0.83 | 2.5 |
| 1174 | 0.6 | 1.1 | 5.9 | 6.7 | 25 | 25.84 | 0.21 | 2.08 | 0.057 | 1.15 | 2.5 |
| 1175 | 1.3 | 1.4 | 5.7 | 5.3 | 53 | 3.44 | 0.42 | 1.04 | 0.012 | 0.94 | 2.5 |
| 1175 | 0.7 | 0.6 | 4.8 | 4.8 | 3 | 7.19 | 0.42 | 1.56 | 0.083 | 0.94 | 2.5 |
| 1176 | 1.0 | 1.1 | 9.0 | 9.2 | 60 | 4.69 | 0.31 | 0.73 | 0.006 | 0.94 | 2.5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1176 | 0.9 | 1.1 | 9.6 | 9.6 | 55 | 5.71 | 0.31 | 0.73 | 0.006 | 0.94 | 2.5 |
| 1177 | 0.6 | 0.9 | 11.5 | 11.6 | 85 | 7.09 | 0.71 | 0.83 | 0.001 | 0.73 | 2.9 |
| 1177 | 1.0 | 0.8 | 12.0 | 12.5 | 85 | 9.79 | 0.21 | 0.83 | 0.007 | 0.83 | 2.9 |
| 1178 | 0.7 | 0.8 | 8.3 | 7.7 | 76 | 4.90 | 0.31 | 0.83 | 0.026 | 0.63 | 3.5 |
| 1178 | 0.9 | 1.0 | 4.8 | 5.3 | 107 | 9.90 | 0.42 | 1.04 | 0.138 | 0.73 | 6.5 |
| 1179 | 0.6 | 0.6 | 7.2 | 7.2 | 0 | 5.31 | 0.31 | 0.73 | 0.002 | 0.73 | 2.2 |
| 1179 | 0.0 | 0.0 | 6.8 | 7.0 | 38 | 7.92 | 0.21 | 1.04 | 0.004 | 0.73 | 2.2 |
| 1180 | 1.0 | 0.8 | 7.7 | 7.9 | 58 | 6.25 | 0.42 | 0.94 | 0.005 | 0.94 | 3.8 |
| 1180 | 0.7 | 0.5 | 8.5 | 8.5 | 37 | 8.86 | 0.31 | 1.25 | 0.078 | 1.25 | 3.5 |
| 1181 | 0.4 | 0.7 | 7.2 | 7.2 | 38 | 4.69 | 0.21 | 0.42 | 0.008 | 0.73 | 3.8 |
| 1181 | 0.5 | 0.6 | 6.8 | 6.8 | 29 | 16.15 | 0.31 | 0.83 | 0.003 | 1.04 | 2.9 |
| 1197 | 3.6 | 3.7 | . | . | 23 | 3.44 | 0.42 | 0.73 | 0.005 | 2.29 | 1.9 |
| 1198 | 3.3 | 3.0 | . | . | 174 | 1.25 | 0.21 | 0.42 | 0.018 | 1.67 | 5.0 |
| 1199 | . | . | . | . | 56 | 2.60 | 0.31 | 0.42 | 0.004 | 1.35 | 1.9 |
| 1200 | 3.4 | 3.9 | . | . | 98 | 1.46 | 0.31 | 0.52 | 0.016 | 1.35 | 7.4 |
| 1201 | . | . | . | . | 30 | 1.98 | 0.42 | 0.42 | 0.005 | 1.56 | 1.3 |
| 1201 | . | . | . | . | 28 | 1.98 | 0.42 | 0.42 | 0.006 | 1.56 | . |
| 1202 | 1.9 | 1.7 | . | . | 3 | 0.94 | 0.42 | 0.31 | 0.033 | 0.83 | 1.9 |
| 1202 | 1.8 | 1.8 | . | . | 9 | 0.94 | 0.31 | 0.31 | 0.033 | 0.73 | 1.9 |
| 1203 | . | . | . | . | 148 | 1.25 | 0.63 | 0.52 | 0.072 | 0.73 | 1.3 |
| 1204 | . | . | . | . | 61 | 1.04 | 0.21 | 0.52 | 0.079 | 0.42 | 1.3 |
| 1212 | . | . | . | . | . | 1.83 | 0.52 | 0.52 | 0.006 | 1.24 | 4.1 |
| 1213 | . | . | . | . | . | 1.58 | 0.26 | 0.99 | 0.017 | 0.89 | 1.1 |
| 1214 | . | . | . | . | . | 2.20 | 0.23 | 0.63 | 0.016 | 3.68 | 1.3 |
| 1215 | . | . | . | . | . | 2.95 | 0.41 | 0.73 | 0.037 | 5.60 | 2.2 |
| 1216 | . | . | . | . | . | 7.43 | 0.52 | 0.75 | 0.008 | 1.00 | 1.9 |
| 1217 | . | . | . | . | . | 1.62 | 0.33 | 0.60 | 0.006 | 1.44 | 1.3 |
| 1218 | . | . | . | . | . | 3.31 | 0.23 | 0.71 | 0.011 | 0.57 | 1.8 |
| 1219 | . | . | . | . | . | 2.60 | 0.56 | 0.71 | 0.009 | 0.73 | 1.3 |
| 1220 | . | . | . | . | . | 2.28 | 0.29 | 0.66 | 0.004 | 0.73 | 1.3 |
| 1221 | . | . | . | . | . | 1.36 | 0.36 | 0.41 | 0.025 | 1.91 | 1.7 |
| 1222 | . | . | . | . | . | 2.65 | 0.46 | 0.59 | 0.006 | 4.44 | 1.7 |
| 1223 | . | . | . | . | . | 1.63 | 0.56 | 0.35 | 0.006 | 1.42 | 1.6 |
| 1224 | . | . | . | . | . | 3.13 | 0.42 | 0.52 | 0.013 | 1.82 | 1.9 |
| 1225 | . | . | . | . | . | 1.83 | 0.26 | 0.30 | 0.017 | 0.97 | . |
| 1226 | . | . | . | . | 286 | 1.26 | 0.16 | 0.21 | 0.030 | 0.38 | . |
| 1226 | . | . | . | . | 286 | 1.25 | 0.19 | 0.21 | 0.031 | 0.35 | . |
| 1227 | . | . | . | . | 103 | 0.59 | 0.09 | 0.35 | 0.061 | 0.48 | 1.3 |
| 1227 | . | . | . | . | 78 | 0.61 | 0.08 | 0.33 | 0.070 | 0.48 | 1.3 |
| 1228 | . | . | . | . | 128 | 1.77 | 0.27 | 0.38 | 0.020 | 0.48 | 2.5 |
| 1228 | . | . | . | . | 362 | 1.67 | 0.23 | 0.39 | 0.020 | 0.49 | 2.5 |
| 1229 | . | . | . | . | . | 0.99 | 0.18 | 0.21 | 0.070 | 0.40 | . |
| 1229 | . | . | . | . | . | 1.01 | 0.21 | 0.22 | 0.070 | 0.41 | . |
| 1230 | . | . | . | . | 68 | 0.88 | 0.10 | 0.25 | 0.033 | 0.39 | 1.3 |
| 1231 | . | . | . | . | 61 | 1.08 | 0.21 | 0.07 | 0.008 | 0.78 | 1.8 |
| 1231 | . | . | . | . | 66 | 1.07 | 0.21 | 0.06 | 0.007 | 0.75 | 1.7 |
| 1232 | . | . | . | . | . | 1.40 | 0.27 | 0.34 | 0.027 | 0.53 | 2.2 |
| 1233 | . | . | . | . | 81 | 1.09 | 0.17 | 0.35 | 0.030 | 0.57 | . |

USFWS ACID RAIN SENSITIVITY PROJECT
STATE OF MASSACHUSETTS

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | HYDRO. | BED ROCK | SOIL TYPE | DISTR. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1050 | ADAMS PD | 110980 | 422113 | 720444 | 290 | 9 | 1 | 5 | 2 | 4 | 3 | 4.3 | 1524 |
| 1051 | BOG PD | 90980 | 423826 | 730228 | 566 | 16 | 1 | 5 | 2 | 5 | 1 | 4.3 | 1321 |
| 1052 | CHARNOCK ROAD PD | 110980 | 422342 | 715758 | 257 | 4 | 1 | 6 | 3 | 4 | 3 | 4.3 | 1524 |
| 1053 | CROW HILL PD | 110980 | 423136 | 715138 | 251 | 4 | 1 | 6 | 1 | 4 | 3 | 4.3 | 1524 |
| 1054 | FOLEY PD | 110980 | 421925 | 720239 | 222 | 2 | 1 | 6 | 2 | 4 | 3 | 4.3 | 1524 |
| 1055 | GOODNOW ROAD PD | 90980 | 423513 | 724500 | 283 | 4 | 1 | 6 | 4 | 5 | 2 | 4.3 | 1321 |
| 1056 | HALLS PD | 100980 | 420617 | 725917 | 385 | 4 | 1 | 6 | 1 | 4 | 2 | 4.3 | 1524 |
| 1057 | HOWE PD | 110980 | 421251 | 720000 | 203 | 4 | 1 | 6 | 3 | 4 | 3 | 4.3 | 1524 |
| 1058 | NORTH POND | 90980 | 423906 | 730317 | 586 | 7 | 1 | 6 | 1 | 5 | 2 | 4.3 | 1321 |
| 1059 | SHEOMET LAKE | 90980 | 424043 | 721806 | 210 | 13 | 1 | 5 | 2 | 4 | 3 | 4.3 | 1321 |
| 1060 | SOUTH PD | 90980 | 423842 | 730306 | 585 | 10 | 1 | 6 | 1 | 5 | 2 | 4.3 | 1321 |
| 1061 | STREETER PD | 110980 | 422008 | 715406 | 317 | 8 | 3 | 5 | 1 | 4 | 2 | 4.3 | 1524 |
| 1062 | UPPER SPECTACLE PD | 100980 | 421043 | 730719 | 437 | 29 | 1 | 5 | 1 | 5 | 2 | 4.3 | 1321 |
| 1063 | WICKETT PD | 90980 | 423305 | 722938 | 325 | 13 | 1 | 6 | 1 | 4 | 2 | 4.3 | 1321 |
| 1064 | WOLF BROOK PD | 120980 | 424155 | 714037 | 98 | 2 | 1 | 6 | 1 | 4 | 3 | 4.3 | 1524 |
| 1065 | LOWER WRIGHT PD | 120980 | 424016 | 714906 | 299 | 9 | 1 | 6 | 1 | 4 | 2 | 4.3 | 1524 |
| 1066 | YORK PD | 100980 | 420629 | 731104 | 471 | 15 | 1 | 6 | 1 | 5 | 2 | 4.3 | 1321 |
| 1127 | BADDACOOK PD | 111180 | 423706 | 713149 | 71 | 31 | 1 | 6 | 3 | 3 | 3 | 4.3 | 1524 |
| 1128 | BALDPATE PD | 101180 | 424147 | 710000 | 28 | 22 | 1 | 6 | 3 | 5 | 3 | 4.3 | 1321 |
| 1129 | BIG BEAR PD | 121180 | 415627 | 705938 | 17 | 15 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1524 |
| 1130 | ECHO LAKE | 121180 | 420949 | 711720 | 82 | 1 | 1 | 6 | 1 | 3 | 2 | 4.3 | 1321 |
| 1131 | HOLTS PD | 121180 | 420946 | 711901 | 52 | 1 | 1 | 5 | 4 | 5 | 2 | 4.3 | 1321 |
| 1132 | JOHN'S PD | 131180 | 415507 | 705035 | 34 | 8 | 1 | 6 | 1 | 4 | 3 | 4.3 | 1524 |
| 1133 | LEACH PD | 121180 | 420348 | 710905 | 63 | 41 | 1 | 6 | 1 | 5 | 2 | 4.3 | 1524 |
| 1134 | LITTLE CLIFF PD | 131180 | 414625 | 700000 | 16 | 12 | 1 | 6 | . | 3 | 3 | 4.3 | 1118 |
| 1135 | LITTLE COLLEGE PD | 131180 | 415418 | 704105 | 30 | 1 | 1 | 6 | 1 | 4 | 1 | 4.3 | 1524 |
| 1136 | LITTLE FARM PD | 111180 | 421500 | 712241 | 41 | 9 | 1 | 6 | 1 | 4 | 3 | 4.3 | 1321 |
| 1137 | MILLHAM STREET PD | 111180 | 421917 | 713613 | 84 | 3 | 1 | 6 | 2 | 4 | 3 | 4.3 | 1321 |
| 1138 | NEW LONG PD | 131180 | 415256 | 704149 | 30 | 9 | 1 | 6 | 1 | 4 | 2 | 4.3 | 1524 |
| 1139 | ROUND PD | 141180 | 423553 | 704901 | 14 | 15 | 1 | 5 | 1 | 4 | 2 | 4.3 | 1321 |
| 1140 | RUTH PD | 131180 | 414537 | 700211 | 16 | 3 | 1 | 6 | . | 3 | 2 | 4.3 | 1118 |
| 1141 | STEARNS PD | 101180 | 423705 | 710404 | 34 | 17 | 1 | 6 | 1 | 4 | 2 | 4.3 | 1321 |
| 1142 | WALDEN PD | 111180 | 422615 | 712018 | 48 | 24 | 1 | 6 | 3 | 3 | 2 | 4.3 | 1321 |
| 1143 | WHEELER PD | 111180 | 422508 | 713117 | 79 | 8 | 1 | 5 | 3 | 3 | 2 | 4.3 | 1321 |

| WATER CODE | DEPTH (M) | TEMP ( C) | PH | PH | ALK (F.E.P) (UEQ/L) | ALK (F.E.P) (UEQ/L) | ALK (I.P) (UEQ/L) | ALK (I.P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1050 | 1 | 21 | 5.69 | 5.60 | 57 | 43 | 14 | 12 | 29 | 29 | 70 | 70 |
| 1050 | 0 | 21 | 5.80 | 5.70 | 55 | 40 | 16 | 12 | 30 | 29 | 60 | 70 |
| 1051 | 0 | 20 | 5.85 | 5.85 | 67 | 51 | 30 | 29 | 18 | 17 | 30 | 30 |
| 1051 | 3 | 20 | 5.55 | 5.85 | 63 | 46 | 25 | 22 | 18 | 17 | 30 | 30 |
| 1052 | 0 | 20 | 6.85 | 6.96 | 229 | 244 | 200 | 203 | 50 | 50 | 20 | 20 |
| 1052 | 3 | 19 | 6.85 | 6.98 | 220 | 246 | 191 | 205 | 49 | 49 | 20 | 20 |
| 1053 | 0 | 21 | 7.12 | 6.45 | 72 | 52 | 32 | 32 | 36 | 35 | 10 | 20 |
| 1053 | 3 | 21 | 6.64 | 6.35 | 72 | 51 | 30 | 26 | 35 | 35 | 10 | 20 |
| 1054 | 0 | 22 | 6.25 | 6.34 | 70 | 85 | 42 | 43 | 28 | 28 | 20 | 30 |
| 1055 | 0 | 22 | 7.40 | 7.59 | 416 | 427 | 389 | 386 | 65 | 59 | 40 | 40 |
| 1055 | 1 | 21 | 7.35 | 7.36 | 398 | 421 | 368 | 376 | 56 | 53 | 40 | 100 |
| 1056 | 0 | 21 | 6.48 | 6.45 | 111 | 99 | 75 | 69 | 26 | 25 | 40 | 40 |
| 1056 | 4 | 18 | 6.07 | 6.10 | 327 | 296 | 285 | 268 | 42 | 42 | 160 | 160 |
| 1057 | 0 | 19 | 6.50 | 6.59 | 168 | 196 | 144 | 151 | 47 | 48 | 40 | 40 |
| 1057 | 2 | 19 | 6.50 | 6.65 | 168 | 194 | 142 | 152 | 49 | 47 | 40 | 40 |
| 1058 | 0 | 22 | 6.65 | 6.56 | 93 | 110 | 70 | 69 | 25 | 22 | 10 | 10 |
| 1058 | 8 | 17 | 6.10 | 6.29 | 208 | 224 | 186 | 185 | 30 | 24 | 30 | 30 |
| 1059 | 0 | 20 | 6.70 | 6.82 | 148 | 164 | 123 | 128 | 32 | 31 | 30 | 20 |
| 1059 | 3 | 20 | 6.65 | 6.68 | 148 | 167 | 117 | 127 | 32 | 30 | 30 | 30 |
| 1060 | 0 | 21 | 5.33 | 4.95 | 43 | 13 | -2 | -8 | 20 | 20 | 0 | 0 |
| 1060 | 3 | 21 | 5.23 | 4.95 | 39 | 16 | -2 | -7 | 20 | 18 | 10 | 10 |
| 1061 | 0 | 20 | 6.58 | 6.45 | 114 | 94 | 73 | 64 | 50 | 49 | 20 | 20 |
| 1061 | 2 | 20 | 6.58 | 6.45 | 111 | 97 | 76 | 66 | 48 | 49 | 10 | 20 |
| 1062 | 0 | 21 | 6.72 | 6.65 | 196 | 183 | 158 | 150 | 50 | 50 | 50 | 50 |
| 1062 | 3 | 21 | 6.75 | 6.70 | 193 | 186 | 152 | 155 | 52 | 52 | 50 | 50 |
| 1063 | 0 | 21 | 4.80 | 4.70 | 22 | 11 | -17 | -23 | 26 | 26 | 10 | 10 |
| 1063 | 1 | 21 | 4.75 | 4.70 | 20 | 11 | -18 | -18 | 23 | 24 | 20 | 10 |
| 1064 | 0 | 19 | 6.55 | 7.06 | 125 | 142 | 96 | 102 | 80 | 90 | 80 | 80 |
| 1064 | 2 | 19 | 6.15 | 6.30 | 168 | 194 | 134 | 149 | 93 | 93 | 90 | 90 |
| 1065 | 0 | 21 | 5.50 | 5.35 | 45 | 30 | 6 | 4 | 32 | 31 | 20 | 20 |
| 1065 | 5 | 20 | 5.43 | 5.25 | 54 | 39 | 15 | 11 | 31 | 32 | 40 | 40 |
| 1066 | 0 | 21 | 7.45 | 7.87 | 348 | 357 | 314 | 321 | 52 | 51 | 20 | 20 |
| 1066 | 3 | 22 | 7.45 | 7.78 | 355 | 365 | 323 | 326 | 51 | 51 | 20 | 20 |
| 1127 | 0 | 5 | 6.55 | 7.06 | 349 | 362 | 319 | 328 | 84 | 86 | 50 | 50 |
| 1127 | 7 | 5 | 6.95 | 7.02 | 351 | 377 | 319 | 323 | 84 | 83 | 50 | 50 |
| 1128 | 0 | 9 | 7.15 | 7.06 | 402 | 418 | 374 | 382 | 190 | 190 | 20 | 20 |
| 1128 | 4 | 8 | 7.15 | 7.10 | 391 | 425 | 354 | 392 | 200 | 190 | 20 | 20 |
| 1129 | 0 | 7 | 7.25 | 7.30 | 288 | 302 | 262 | 261 | 110 | 115 | 30 | 20 |
| 1129 | 1 | 7 | 7.25 | 7.30 | 286 | 300 | 258 | 261 | 110 | 115 | 20 | 20 |
| 1130 | 0 | 4 | 6.50 | 6.50 | 103 | 99 | 66 | 66 | 38 | 38 | 40 | 40 |
| 1130 | 1 | 4 | 6.50 | 6.45 | 102 | 97 | 67 | 66 | 37 | 37 | 40 | 40 |
| 1131 | 0 | 5 | 5.34 | 5.30 | 45 | 35 | 6 | 3 | 160 | 150 | 40 | 40 |
| 1131 | 1 | 4 | 5.35 | 5.30 | 42 | 35 | 2 | 1 | 150 | 150 | 40 | 40 |
| 1132 | 0 | 6 | 5.15 | 4.95 | 28 | 14 | -5 | -6 | 38 | 38 | 0 | 0 |
| 1132 | 4 | 7 | 5.06 | 4.95 | 25 | 14 | -5 | -6 | 38 | 38 | 0 | 0 |
| 1133 | 0 | 5 | 6.10 | 6.07 | 50 | 57 | 22 | 21 | 42 | 44 | 20 | 10 |
| 1133 | 1 | 5 | 6.10 | 6.03 | 50 | 56 | 18 | 20 | 42 | 42 | 20 | 20 |
| 1134 | 0 | 7 | 7.00 | 6.82 | 133 | 128 | 110 | 102 | 88 | 82 | 0 | 0 |
| 1134 | 4 | 7 | 6.95 | 6.83 | 125 | 131 | 137 | 102 | 86 | 82 | 0 | 0 |
| 1135 | 0 | 6 | 4.30 | 4.46 | 0 | 0 | -38 | -34 | 52 | 52 | 20 | 20 |
| 1135 | 1 | 6 | 4.30 | 4.47 | 0 | 0 | -35 | -35 | 52 | 52 | 20 | 20 |
| 1136 | 0 | 6 | 7.36 | 7.25 | 505 | 491 | 474 | 462 | 110 | 105 | 20 | 20 |
| 1136 | 3 | 5 | 7.34 | 7.25 | 500 | 491 | 464 | 462 | 105 | 105 | 20 | 20 |
| 1137 | 0 | 5 | 7.05 | 7.06 | 309 | 323 | 275 | 294 | 135 | 120 | 40 | 40 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1137 | 2 | 5 | 7.00 | 7.05 | 321 | 323 | 289 | 291 | 125 | 120 | 40 | 50 |
| 1138 | 0 | 7 | 5.40 | 5.48 | 23 | 39 | 1 | 6 | 41 | 40 | 10 | 10 |
| 1138 | 1 | 7 | 5.40 | 5.49 | 26 | 34 | 6 | 4 | 40 | 39 | 10 | 10 |
| 1139 | 0 | 8 | 7.25 | 7.22 | 309 | 304 | 248 | 271 | 130 | 130 | 50 | 50 |
| 1139 | 3 | 8 | 7.25 | 7.25 | 307 | 307 | 269 | 269 | 130 | 120 | 50 | 50 |
| 1140 | 0 | 6 | 4.58 | 4.85 | 26 | 14 | -4 | -9 | 80 | 80 | 10 | 10 |
| 1140 | 3 | 6 | 4.98 | 4.85 | 26 | 14 | -2 | -9 | 79 | 80 | 10 | 10 |
| 1141 | 0 | 7 | 6.54 | 6.50 | 104 | 97 | 75 | 69 | 56 | 48 | 30 | 30 |
| 1141 | 1 | 7 | 6.64 | 6.55 | 110 | 102 | 70 | 67 | 48 | 48 | 30 | 30 |
| 1142 | 0 | 8 | 6.85 | 6.92 | 166 | 171 | 147 | 155 | 72 | 72 | 10 | 10 |
| 1142 | 3 | 8 | 6.90 | 6.86 | 169 | 188 | 145 | 148 | 77 | 73 | 10 | 10 |
| 1143 | 0 | 4 | 7.15 | 7.05 | 350 | 356 | 329 | 327 | 160 | 160 | 20 | 20 |
| 1143 | 1 | 5 | 7.17 | 7.05 | 365 | 357 | 325 | 336 | 160 | 160 | 20 | 20 |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | TOC (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1050 | 2.0 | 1.9 | 6.4 | 6.5 | 138 | 1.67 | 0.58 | 0.50 | 0.024 | 2.21 | 5.6 |
| 1050 | 2.1 | 2.0 | 6.4 | 6.2 | 132 | 1.67 | 0.61 | 0.50 | 0.024 | 2.22 | 5.3 |
| 1051 | 0.0 | 0.0 | 5.9 | 5.3 | 60 | 1.82 | 0.23 | 0.34 | 0.023 | 0.51 | 3.2 |
| 1051 | 0.0 | 0.0 | 4.8 | 5.3 | 48 | 1.82 | 0.22 | 0.32 | 0.022 | 0.50 | 3.2 |
| 1052 | 1.5 | 1.5 | 8.5 | 8.2 | 74 | 4.91 | 1.11 | 0.88 | 0.017 | 2.35 | 2.5 |
| 1052 | 2.1 | 2.2 | 8.3 | 8.3 | 67 | 4.93 | 1.10 | 0.90 | 0.019 | 2.33 | 2.5 |
| 1053 | 4.9 | 5.2 | 4.5 | 4.2 | 50 | 1.10 | 0.69 | 0.28 | 0.044 | 4.49 | 2.2 |
| 1053 | 6.1 | 6.2 | 4.3 | 4.6 | 36 | 1.09 | 0.68 | 0.28 | 0.046 | 4.48 | 2.2 |
| 1054 | 4.6 | 4.7 | 6.4 | 5.9 | 55 | 1.05 | 0.95 | 0.45 | 0.023 | 2.81 | 2.9 |
| 1055 | 1.9 | 2.0 | 6.6 | 6.0 | 96 | 8.15 | 0.92 | 0.73 | 0.083 | 2.66 | 3.8 |
| 1055 | 4.1 | 4.1 | 6.0 | 5.9 | 14 | 8.18 | 0.91 | 0.78 | 0.123 | 2.59 | 5.6 |
| 1056 | 0.3 | 0.4 | 5.4 | 5.5 | 271 | 4.23 | 1.13 | 0.76 | 0.137 | 1.16 | 3.8 |
| 1056 | 0.7 | 0.6 | 4.8 | 4.8 | 71 | 2.00 | 0.44 | 0.66 | 0.029 | 1.18 | 11.1 |
| 1057 | 4.6 | 4.5 | 7.0 | 6.8 | 90 | 3.07 | 1.20 | 0.94 | 0.033 | 3.83 | 3.8 |
| 1057 | 4.1 | 4.1 | 7.0 | 7.0 | 90 | 3.15 | 1.16 | 0.92 | 0.033 | 3.81 | 3.8 |
| 1058 | 0.0 | 0.0 | 5.8 | 6.0 | 50 | 2.58 | 0.76 | 0.54 | 0.052 | 0.58 | 1.9 |
| 1058 | 0.0 | 0.0 | 5.0 | 4.9 | 169 | 3.24 | 0.80 | 0.53 | 0.419 | 0.57 | 3.2 |
| 1059 | 1.5 | 1.4 | 5.4 | 5.4 | 31 | 2.55 | 1.04 | 0.77 | 0.173 | 2.03 | 2.9 |
| 1059 | 1.7 | 1.0 | 5.7 | 5.7 | 2 | 2.55 | 1.05 | 0.77 | 0.125 | 2.04 | 3.2 |
| 1060 | 0.0 | 0.0 | 6.5 | 6.5 | 67 | 1.30 | 0.47 | 0.27 | 0.033 | 0.48 | 1.3 |
| 1060 | 0.0 | 0.0 | 6.1 | 6.1 | 81 | 1.63 | 0.47 | 0.27 | 0.034 | 0.48 | 1.9 |
| 1061 | 8.1 | 8.1 | 7.2 | 6.7 | 38 | 2.50 | 0.95 | 0.60 | 0.011 | 5.06 | 2.5 |
| 1061 | 8.2 | 8.2 | 6.5 | 6.5 | 26 | 2.43 | 0.92 | 0.60 | 0.012 | 5.00 | 2.2 |
| 1062 | 4.7 | 4.9 | 8.5 | 8.5 | 31 | 3.97 | 0.97 | 1.34 | 0.067 | 3.23 | 4.4 |
| 1062 | 5.1 | 5.0 | 8.4 | 8.6 | 39 | 3.97 | 0.97 | 1.34 | 0.061 | 3.23 | 4.4 |
| 1063 | 0.0 | 0.0 | 7.2 | 7.2 | 151 | 1.00 | 0.09 | 0.23 | 0.043 | 1.39 | 1.9 |
| 1063 | 0.0 | 0.0 | 7.1 | 7.9 | 161 | 1.03 | 0.22 | 0.24 | 0.035 | 1.35 | 2.2 |
| 1064 | 19.6 | 19.1 | 6.7 | 6.5 | 81 | 3.29 | 1.26 | 0.76 | 0.039 | 12.44 | 6.2 |
| 1064 | 17.7 | 17.7 | 5.9 | 5.6 | 122 | 3.66 | 1.35 | 0.82 | 0.154 | 12.01 | 6.8 |
| 1065 | 3.7 | 3.8 | 6.2 | 5.9 | 40 | 1.03 | 0.53 | 0.31 | 0.038 | 3.61 | 2.5 |
| 1065 | 5.0 | 5.6 | 6.1 | 5.5 | 113 | 1.09 | 0.64 | 0.31 | 0.040 | 3.62 | 3.8 |
| 1066 | 1.0 | 1.2 | 7.2 | 7.2 | 26 | 5.56 | 0.20 | 1.85 | 0.044 | 1.17 | 2.5 |
| 1066 | 0.3 | 0.0 | 7.0 | 7.0 | 25 | 5.53 | 0.20 | 1.88 | 0.054 | 1.17 | 2.5 |
| 1127 | 11.5 | 11.1 | 7.2 | 7.2 | 16 | 8.38 | 1.82 | 1.05 | 0.154 | 5.78 | 4.4 |
| 1127 | 11.5 | 11.5 | 7.2 | 7.2 | 23 | 8.22 | 1.82 | 1.04 | 0.154 | 5.66 | 4.4 |
| 1128 | 0.0 | 0.0 | 6.5 | 6.4 | 0 | 9.25 | 1.53 | 2.34 | 0.071 | 10.60 | 2.5 |
| 1128 | 0.0 | 0.0 | 5.9 | 5.6 | 41 | 9.33 | 1.56 | 2.37 | 0.077 | 10.72 | 2.5 |
| 1129 | 8.7 | 9.2 | 6.7 | 6.3 | 0 | 7.47 | 1.02 | 1.80 | 0.009 | 9.34 | 2.9 |
| 1129 | 8.1 | 8.7 | 5.9 | 6.0 | 50 | 7.30 | 1.00 | 1.76 | 0.010 | 9.29 | 2.5 |
| 1130 | 5.4 | 4.9 | 5.9 | 5.8 | 29 | 1.79 | 0.41 | 0.82 | 0.020 | 2.75 | 3.8 |
| 1130 | 5.4 | 5.3 | 5.9 | 6.8 | 200 | 1.80 | 0.41 | 0.83 | 0.020 | 2.76 | 3.8 |
| 1131 | 2.5 | 3.0 | 45.6 | 43.7 | 165 | 16.67 | 0.61 | 3.15 | 0.332 | 3.98 | 3.8 |
| 1131 | 4.5 | 4.5 | 43.2 | 42.7 | 205 | 17.19 | 0.63 | 3.17 | 0.368 | 4.07 | 3.8 |
| 1132 | 7.1 | 6.9 | 6.5 | 6.1 | 50 | 0.94 | 1.15 | 0.70 | 0.058 | 3.72 | 1.3 |
| 1132 | 9.3 | 9.0 | 6.0 | 5.9 | 65 | 0.92 | 1.15 | 0.70 | 0.051 | 3.67 | 1.3 |
| 1133 | 6.8 | 6.8 | 7.2 | 6.7 | 69 | 2.06 | 0.46 | 0.76 | 0.040 | 4.19 | 2.2 |
| 1133 | 6.7 | 6.6 | 6.4 | 6.4 | 89 | 2.07 | 0.46 | 0.77 | 0.041 | 4.21 | 2.5 |
| 1134 | 15.5 | 15.2 | 6.7 | 6.5 | 37 | 3.29 | 0.68 | 1.41 | 0.009 | 9.52 | 1.3 |
| 1134 | 15.0 | 15.2 | 6.9 | 6.5 | 55 | 3.21 | 0.65 | 1.38 | 0.009 | 9.48 | 1.3 |
| 1135 | 8.7 | 8.7 | 6.6 | 6.4 | 52 | 0.60 | 0.75 | 0.90 | 0.025 | 4.80 | 2.5 |
| 1135 | 8.6 | 8.6 | 6.1 | 5.9 | 52 | 0.63 | 0.75 | 0.92 | 0.018 | 4.88 | 2.5 |
| 1136 | 12.6 | 12.7 | 7.3 | 7.2 | 4 | 8.23 | 1.10 | 1.95 | 0.103 | 7.25 | 2.5 |
| 1136 | 13.0 | 12.6 | 7.8 | 7.2 | 10 | 8.38 | 1.11 | 1.97 | 0.038 | 7.26 | 2.5 |
| 1137 | 17.5 | 16.9 | 7.1 | 6.8 | 29 | 6.05 | 1.98 | 1.35 | 0.037 | 13.93 | 3.8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1137 | 17.7 | 17.4 | 6.7 | 6.5 | 23 | 6.13 | 1.96 | 1.35 | 0.037 | 13.80 | 4.1 |
| 1138 | 7.7 | 7.1 | 6.6 | 5.8 | 12 | 0.69 | 0.56 | 0.97 | 0.025 | 4.60 | 1.9 |
| 1138 | 7.2 | 7.1 | 6.3 | 6.1 | 16 | 0.71 | 0.56 | 0.96 | 0.024 | 4.58 | 1.9 |
| 1139 | 20.7 | 20.4 | 7.2 | 7.2 | 0 | 6.30 | 1.35 | 2.09 | 0.064 | 13.17 | 4.4 |
| 1139 | 20.1 | 20.0 | 7.2 | 7.2 | 10 | 6.39 | 1.33 | 2.12 | 0.084 | 13.41 | 4.4 |
| 1140 | 16.0 | 16.4 | 7.2 | 7.2 | 40 | 1.03 | 0.61 | 1.52 | 0.026 | 9.62 | 1.9 |
| 1140 | 16.2 | 15.9 | 7.9 | 7.9 | 40 | 1.06 | 0.61 | 1.53 | 0.024 | 9.67 | 1.9 |
| 1141 | 6.8 | 6.8 | 6.6 | 6.5 | 56 | 3.54 | 0.51 | 0.78 | 0.010 | 3.73 | 3.2 |
| 1141 | 6.8 | 6.7 | 7.2 | 6.6 | 79 | 3.45 | 0.52 | 0.78 | 0.030 | 3.77 | 3.2 |
| 1142 | 13.2 | 13.2 | 6.1 | 6.1 | 0 | 4.05 | 1.26 | 0.94 | 0.026 | 7.37 | 1.9 |
| 1142 | 13.0 | 12.9 | 6.2 | 6.1 | 31 | 4.00 | 1.27 | 0.95 | 0.038 | 7.44 | 1.9 |
| 1143 | 20.7 | 20.2 | 15.8 | 15.8 | 12 | 12.46 | 2.87 | 2.38 | 0.025 | 13.10 | 2.5 |
| 1143 | 19.9 | 19.9 | 15.2 | 15.5 | 146 | 12.31 | 2.86 | 2.35 | 0.015 | 13.11 | 2.5 |

USFWS ACID RAIN SENSITIVITY PROJECT
STATE OF NEW HAMPSHIRE

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | HYDRO. | BED ROCK | SOIL TYPE | DISTR. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1020 | COLD RIVER | 70880 | 431556 | 721343 | 244 | 6 | 2 | 2 | 2 | 5 | 2 | 4.3 | 1118 |
| 1021 | CRESCENT PD OUTLET | 80880 | 431556 | 721427 | 366 | 2 | 2 | 1 | 2 | 5 | 2 | 4.3 | 1118 |
| 1022 | GREAT BRK HDWS | 70880 | 430853 | 721544 | 213 | 2 | 2 | 2 | 2 | 5 | 2 | 4.3 | 1118 |
| 1023 | NEWELL PD OUTLET | 70880 | 430811 | 721522 | 426 | 2 | 2 | 1 | 2 | 5 | 2 | 4.3 | 1118 |
| 1031 | BEAVER BRK | 290880 | 432627 | 721236 | 274 | 2 | 2 | 4 | 1 | 5 | 1 | 4.3 | 1118 |
| 1032 | CHAPIN PD OUTLET | 290880 | 432522 | 721724 | 485 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1033 | DODGE BRK | 290880 | 432627 | 721533 | 305 | 1 | 2 | 1 | 1 | 5 | 1 | 4.3 | 1118 |
| 1034 | GOVERNOR'S PD OUTLET | 290880 | 432700 | 721746 | 404 | 2 | 2 | 2 | 2 | 5 | 1 | 4.3 | 1118 |
| 1035 | WEST AMMONOOSUC R. | 250880 | 442855 | 711930 | 457 | 5 | 2 | 2 | 1 | 5 | 2 | 4.2 | 914 |
| 1036 | ATWOOD PD | 270880 | 435230 | 713336 | 460 | 1 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1037 | BACON PD | 280880 | 431317 | 720551 | 500 | 5 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1038 | DURGIN PD | 260880 | 435246 | 711055 | 168 | 6 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1118 |
| 1040 | FLETCHER POND | 280880 | 431227 | 720646 | 497 | 6 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1041 | FROG PD | 280880 | 431219 | 720529 | 491 | 10 | 1 | 5 | 1 | 5 | 1 | 4.3 | 1118 |
| 1042 | UPPER HALL PD | 270880 | 435158 | 713906 | 484 | 19 | 1 | 5 | 2 | 5 | 1 | 4.3 | 1118 |
| 1043 | MIDDLE HALL PD | 270880 | 435136 | 713244 | 445 | 3 | 1 | 5 | 2 | 5 | 1 | 4.3 | 1118 |
| 1044 | LOWER HALL PD | 290880 | 435126 | 713236 | 418 | 8 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1118 |
| 1045 | HEDGEHOG PD | 280880 | 431219 | 720657 | 506 | 3 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1046 | KIAH PD | 270880 | 435117 | 713105 | 433 | 2 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1118 |
| 1047 | MOUNTAIN PD | 260880 | 441011 | 710401 | 499 | 50 | 1 | 5 | 1 | 5 | 1 | 4.3 | 914 |
| 1048 | NORTH PD | 280880 | 431420 | 720402 | 504 | 21 | 1 | 5 | 2 | 5 | 2 | 4.3 | 1118 |
| 1069 | ADAMS PD | 250980 | 431741 | 711427 | 203 | 8 | 1 | 6 | 2 | 3 | 3 | 4.3 | 1118 |
| 1070 | BEAR PD | 270980 | 432917 | 711142 | 271 | 5 | 1 | 6 | 1 | 3 | 2 | 4.3 | 1118 |
| 1071 | CLOUGH PD | 230980 | 432403 | 712621 | 206 | 4 | 1 | 6 | 2 | 3 | 2 | 4.3 | 1118 |
| 1072 | COLDRAIN PD | 220980 | 432703 | 710847 | 201 | 11 | 1 | 6 | 2 | 3 | 1 | 4.3 | 1118 |
| 1073 | CRANEY PD | 240980 | 430842 | 714723 | 304 | 14 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1118 |
| 1074 | CROOKED PD | 250980 | 431741 | 712567 | 158 | '2 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1075 | DUDLEY PD | 240980 | 430658 | 714965 | 255 | 12 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1118 |
| 1076 | EATON PD | 250980 | 431620 | 711701 | 227 | 7 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1077 | FERRIN PD | 240980 | 430232 | 714639 | 288 | 5 | 1 | 5 | 2 | 3 | 1 | 4.3 | 1321 |
| 1078 | GILMAN PD | 220980 | 433040 | 711204 | 230 | 13 | 1 | 5 | 1 | 3 | 1 | 4.3 | 1118 |
| 1079 | HUNKINS PD | 230980 | 433074 | 713339 | 299 | 6 | 1 | 6 | 2 | 3 | 3 | 4.3 | 1118 |
| 1080 | KENISON PD | 250980 | 430901 | 710920 | 93 | 8 | 1 | 6 | 1 | 3 | 2 | 4.3 | 1118 |
| 1081 | KNIGHTS PD | 230980 | 433241 | 711047 | 200 | 12 | 1 | 5 | 1 | 3 | 1 | 4.3 | 1118 |
| 1082 | KNOWLES PD | 230980 | 432543 | 713223 | 227 | 24 | 1 | 6 | 2 | 3 | 1 | 4.3 | 1118 |
| 1083 | LITTLE LONG PD | 250980 | 431612 | 710139 | 76 | 9 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1321 |
| 1084 | LONG PD | 240980 | 430449 | 713613 | 188 | 13 | 1 | 5 | 2 | 3 | 1 | 4.3 | 1321 |
| 1085 | MIDDLE PD | 240980 | 431155 | 714806 | 155 | 1 | 1 | 5 | 2 | 3 | 1 | 4.3 | 1118 |
| 1086 | POVERTY PD | 230980 | 433032 | 714817 | 361 | 4 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1087 | STONEHOUSE PD | 250980 | 431155 | 710551 | 116 | 6 | 1 | 5 | 2 | 3 | 1 | 4.3 | 1321 |
| 1088 | UPPER PD | 240980 | 431211 | 714806 | 155 | 10 | 1 | 5 | 2 | 3 | 2 | 4.3 | 1118 |
| 1191 | GREAT BRK MOUTH | 70880 | 430810 | 722420 | 91 | 5 | 2 | 4 | 2 | 5 | 3 | 4.3 | 1118 |
| 1192 | WARREN BRK MOUTH | 70880 | 430858 | 722166 | . | 5 | 2 | 4 | 2 | 5 | 3 | 4.3 | 1118 |
| 1250 | CONE MTN. PD | 90879 | 435413 | 713619 | 469 | 4 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1251 | UNKNOWN PD | 10878 | 443057 | 712437 | 976 | 1 | 1 | 6 | 1 | 5 | 1 | 4.3 | 1016 |
| 1252 | LOWER SAWYER PD | 220879 | 440258 | 712230 | 551 | 70 | 1 | 5 | 1 | 5 | 1 | 4.3 | 1118 |
| 1253 | BLACK MTN PD | 51079 | 435258 | 713025 | 702 | 2 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1254 | SOLITUDE PD | 261079 | 431839 | 720438 | 779 | 2 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |

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| WATER CODE | DEPTH (M) | TEMP (C) | PH | PH | ALK (F.E.P) (UEQ/L) | ALK (F.E.P) (UEQ/L) | ALK (I.P) (UEQ/L) | ALK (I.P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1020 | 0 | - | 6.85 | 6.85 | 177 | 183 | 144 | 148 | 64 | 64 | 60 | 60 |
| 1021 | 0 | - | 6.55 | 6.55 | 109 | 93 | 70 | 61 | 34 | 37 | 10 | 10 |
| 1022 | 0 | - | 6.50 | 6.55 | 194 | 199 | 164 | 165 | 65 | 66 | 10 | 10 |
| 1023 | 0 | - | 6.55 | 6.55 | 197 | 197 | 165 | 167 | 37 | 37 | 30 | 30 |
| 1031 | 0 | 19 | 7.10 | 7.15 | 222 | 220 | 185 | 181 | 35 | 35 | 60 | 60 |
| 1032 | 0 | 16 | 6.30 | 6.35 | 196 | 197 | 105 | 100 | 22 | 22 | 50 | 50 |
| 1033 | 0 | 15 | 6.85 | 6.85 | 369 | 351 | 319 | 316 | 52 | 51 | 10 | 10 |
| 1034 | 0 | 17 | 6.15 | 6.10 | 47 | 47 | 17 | 17 | 20 | 21 | 10 | 10 |
| 1035 | 0 | 16 | 6.65 | 6.65 | 140 | 140 | 110 | 109 | 27 | 27 | 10 | 10 |
| 1036 | 0 | 25 | 6.55 | 6.55 | 108 | 104 | 58 | 60 | 23 | 23 | 50 | 50 |
| 1036 | 4 | 18 | 6.20 | 6.20 | 597 | 602 | 546 | 551 | 63 | 63 | 130 | 130 |
| 1037 | 0 | 23 | 5.85 | 5.85 | 47 | 47 | 10 | 11 | 20 | 20 | 20 | 20 |
| 1037 | 3 | 22 | 5.70 | 5.75 | 48 | 48 | 16 | 16 | 20 | 20 | 20 | 20 |
| 1038 | 0 | 26 | 6.60 | 6.55 | 160 | 136 | 95 | 97 | 26 | 24 | 30 | 30 |
| 1038 | 4 | 25 | 5.55 | 5.95 | 145 | 151 | 106 | 106 | 24 | 26 | 40 | 40 |
| 1040 | 0 | 23 | 5.65 | 5.75 | 43 | 47 | 7 | 7 | 22 | 22 | 10 | 10 |
| 1040 | 2 | 23 | 5.30 | 5.80 | 48 | 48 | 14 | 17 | 22 | 22 | 10 | 10 |
| 1041 | 0 | 23 | 5.50 | 5.55 | 38 | 39 | 4 | 9 | 22 | 22 | 10 | 10 |
| 1041 | 4 | 22 | 5.65 | 5.45 | 39 | 39 | 9 | 9 | 22 | 22 | 20 | 20 |
| 1042 | 0 | 23 | 6.00 | 5.95 | 52 | 50 | 16 | 16 | 20 | 20 | 10 | 10 |
| 1042 | 5 | 21 | 5.85 | 5.85 | 55 | 50 | 13 | 16 | 20 | 22 | 10 | 10 |
| 1043 | 0 | 23 | 6.45 | 6.65 | 68 | 72 | 67 | 41 | 20 | 21 | 0 | 0 |
| 1043 | 15 | 15 | 5.50 | 5.50 | 60 | 56 | 26 | 26 | 21 | 21 | 20 | 20 |
| 1044 | 0 | 25 | 6.20 | 6.75 | 59 | 77 | 34 | 30 | 21 | 21 | 0 | 0 |
| 1044 | 1 | 25 | 6.20 | 6.75 | 81 | 80 | 41 | 41 | 21 | 21 | 0 | 0 |
| 1045 | 0 | 21 | 5.20 | 5.25 | 52 | 37 | 0 | 1 | 86 | 86 | 20 | 20 |
| 1045 | 4 | 20 | 5.35 | 5.35 | 47 | 43 | 11 | 12 | 85 | 88 | 60 | 60 |
| 1046 | 0 | 22 | 6.40 | 6.35 | 81 | 81 | 41 | 41 | 24 | 24 | 40 | 40 |
| 1046 | 5 | 17 | 6.30 | 6.75 | 306 | 318 | 267 | 272 | 42 | 41 | 120 | 120 |
| 1047 | 0 | 19 | 6.75 | 6.30 | 51 | 50 | 14 | 16 | 15 | 15 | 10 | 10 |
| 1047 | 4 | 21 | 6.25 | 6.20 | 54 | 51 | 19 | 21 | 14 | 15 | 10 | 10 |
| 1048 | 0 | 21 | 5.65 | 5.60 | 50 | 47 | 11 | 19 | 21 | 21 | 30 | 30 |
| 1048 | 4 | 19 | 5.45 | 5.45 | 48 | 48 | 13 | 16 | 20 | 21 | 30 | 30 |
| 1049 | 0 | 19 | 6.22 | 6.55 | 170 | 95 | 81 | 68 | 24 | 24 | 10 | 10 |
| 1049 | 5 | 13 | 6.12 | 6.05 | 186 | 159 | 143 | 129 | 26 | 27 | 20 | 20 |
| 1070 | 0 | 22 | 6.65 | 6.73 | 91 | 100 | 64 | 68 | 22 | 21 | 10 | 10 |
| 1070 | 4 | 21 | 6.20 | 6.78 | 91 | 101 | 63 | 65 | 21 | 20 | 10 | 10 |
| 1071 | 0 | 20 | 6.95 | 6.75 | 135 | 126 | 103 | 107 | 24 | 22 | 0 | 10 |
| 1071 | 5 | 19 | 6.54 | 6.40 | 136 | 126 | 103 | 100 | 23 | 23 | 0 | 10 |
| 1072 | 0 | 21 | 5.79 | 5.65 | 60 | 67 | 26 | 18 | 18 | 18 | 100 | 100 |
| 1072 | 4 | 18 | 5.75 | 5.80 | 85 | 75 | 50 | 46 | 20 | 21 | 100 | 100 |
| 1073 | 0 | 19 | 6.19 | 5.95 | 65 | 60 | 25 | 27 | 22 | 21 | 30 | 30 |
| 1073 | 4 | 18 | 5.92 | 5.80 | 65 | 56 | 25 | 23 | 22 | 21 | 30 | 30 |
| 1074 | 0 | 19 | 6.25 | 6.33 | 99 | 119 | 66 | 77 | 24 | 23 | 20 | 10 |
| 1074 | 5 | 18 | 6.05 | 6.15 | 111 | 128 | 82 | 88 | 26 | 26 | 30 | 20 |
| 1075 | 0 | 19 | 6.65 | 6.72 | 113 | 127 | 87 | 99 | 30 | 30 | 10 | 10 |
| 1075 | 6 | 18 | 6.35 | 6.44 | 116 | 137 | 87 | 96 | 31 | 30 | 10 | 20 |
| 1076 | 0 | 18 | 5.80 | 5.70 | 81 | 62 | 38 | 35 | 42 | 42 | 80 | 80 |
| 1076 | 4 | 17 | 5.53 | 5.80 | 104 | 122 | 119 | 98 | 48 | 47 | 110 | 120 |
| 1077 | 0 | 20 | 6.33 | 6.00 | 61 | 48 | 24 | 21 | 22 | 21 | 10 | 10 |
| 1077 | 3 | 20 | 6.32 | 5.95 | 67 | 48 | 25 | 21 | 20 | 20 | 10 | 10 |
| 1078 | 0 | 21 | 6.78 | 6.60 | 128 | 124 | 92 | 91 | 22 | 22 | 40 | 40 |
| 1078 | 4 | 19 | 6.65 | 6.50 | 136 | 122 | 97 | 95 | 22 | 22 | 40 | 30 |
| 1079 | 0 | 21 | 7.35 | 7.45 | 981 | 990 | 954 | 960 | 98 | 96 | 10 | 10 |

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| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1079 | 5 | 19 | 6.95 | 7.22 | 392 | 407 | 367 | 368 | 97 | 94 | 10 | 10 |
| 1080 | 0 | 19 | 5.55 | 6.05 | 68 | 86 | 44 | 48 | 31 | 31 | 60 | 60 |
| 1080 | 7 | 9 | 5.85 | 6.03 | 263 | 310 | 226 | 261 | 39 | 38 | 110 | 200 |
| 1081 | 0 | 21 | 7.20 | 6.95 | 242 | 233 | 206 | 200 | 30 | 28 | 10 | 10 |
| 1081 | 3 | 20 | 7.20 | 6.95 | 245 | 240 | 206 | 203 | 28 | 29 | 10 | 10 |
| 1082 | 0 | 20 | 6.35 | 6.39 | 57 | 70 | 36 | 35 | 22 | 22 | 0 | 0 |
| 1082 | 10 | 18 | 5.55 | 6.10 | 65 | 80 | 40 | 45 | 28 | 22 | 10 | 0 |
| 1083 | 0 | 19 | 6.01 | 5.90 | 92 | 75 | 54 | 53 | 53 | 51 | 60 | 70 |
| 1083 | 5 | 13 | 6.09 | 6.05 | 404 | 333 | 359 | 306 | 76 | 76 | 130 | 160 |
| 1084 | 0 | 20 | 5.40 | 5.42 | 32 | 42 | 8 | 3 | 21 | 20 | 20 | 30 |
| 1084 | 5 | 18 | 5.35 | 5.45 | 50 | 57 | 23 | 18 | 22 | 21 | 70 | 80 |
| 1085 | 0 | 19 | 6.65 | 6.86 | 147 | 158 | 118 | 118 | 26 | 26 | 30 | 40 |
| 1085 | 5 | 12 | 5.85 | 5.95 | 244 | 272 | 218 | 227 | 38 | 38 | 80 | 70 |
| 1086 | 0 | 21 | 5.62 | 5.55 | 48 | 39 | 12 | 9 | 20 | 20 | 10 | 10 |
| 1086 | 5 | 18 | 5.76 | 5.65 | 47 | 36 | 11 | 7 | 20 | 19 | 0 | 10 |
| 1087 | 0 | 19 | 5.70 | 5.77 | 39 | 50 | 14 | 10 | 20 | 20 | 20 | 20 |
| 1087 | 15 | 7 | 6.00 | 6.20 | 237 | 277 | 207 | 233 | 30 | 29 | 70 | 70 |
| 1088 | 0 | 19 | 6.59 | 6.40 | 169 | 154 | 124 | 122 | 26 | 26 | 40 | 40 |
| 1088 | 5 | 15 | 6.18 | 6.10 | 449 | 433 | 398 | 395 | 51 | 50 | 60 | . |
| 1191 | 0 | . | 7.25 | 7.25 | 457 | 468 | 423 | 432 | 94 | 93 | 0 | 0 |
| 1192 | 0 | . | 7.10 | 7.10 | 269 | 262 | 248 | 232 | 81 | 80 | 20 | 20 |
| 1250 | 0 | . | 4.48 | . | 0 | 0 | -23 | . | 25 | . | 5 | . |
| 1250 | 6 | . | 4.40 | . | 0 | 0 | -26 | . | 29 | . | 0 | . |
| 1251 | 1 | . | 4.35 | . | 0 | 0 | 0 | . | 18 | . | 30 | . |
| 1251 | 3 | . | 4.35 | . | 0 | . | . | . | 17 | . | . | . |
| 1252 | 1 | 19 | 6.55 | . | 119 | . | 71 | . | 19 | . | . | . |
| 1252 | 10 | 10 | 6.10 | . | 154 | . | 117 | . | 21 | . | . | . |
| 1253 | 1 | 15 | 5.25 | . | 44 | . | 0 | . | 20 | . | 10 | . |
| 1253 | 8 | . | 5.60 | . | 47 | . | 10 | . | 20 | . | . | . |
| 1254 | 1 | 10 | 4.55 | . | 21 | . | -10 | . | 20 | . | 25 | . |
| 1254 | 6 | 7 | 4.95 | . | 22 | . | -8 | . | 20 | . | 40 | . |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | TOC (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1020 | 10.5 | 10.9 | 6.2 | 6.0 | 117 | 3.71 | 1.18 | 0.83 | 0.055 | 6.56 | 5.0 |
| 1021 | 3.3 | 3.4 | 5.4 | 5.6 | 15 | 2.24 | 0.81 | 0.58 | 0.074 | 2.40 | 1.9 |
| 1022 | 2.4 | 2.3 | 7.3 | 7.2 | 21 | 4.15 | 0.98 | 0.83 | 0.129 | 2.72 | 1.9 |
| 1023 | 0.6 | 0.7 | 6.1 | 5.9 | 60 | 2.98 | 1.46 | 0.93 | 0.013 | 2.12 | 3.2 |
| 1031 | 1.0 | 1.1 | 5.3 | 4.8 | 70 | 3.70 | 0.63 | 0.65 | 0.059 | 1.42 | 5.0 |
| 1032 | 0.6 | 0.4 | 3.6 | 3.2 | 115 | 1.88 | 0.29 | 0.55 | 0.080 | 1.00 | 4.4 |
| 1033 | 0.6 | 0.5 | 7.5 | 7.6 | 19 | 4.97 | 0.84 | 1.28 | 0.014 | 2.15 | 1.9 |
| 1034 | 0.6 | 0.6 | 6.2 | 6.1 | 22 | 1.23 | 0.33 | 0.44 | 0.026 | 0.91 | 1.9 |
| 1035 | 2.5 | 2.4 | 4.5 | 4.5 | 63 | 2.39 | 0.72 | 0.39 | 0.017 | 1.46 | 1.9 |
| 1036 | 1.0 | 0.6 | 5.6 | 5.4 | 93 | 1.98 | 0.42 | 0.39 | 0.130 | 1.35 | 4.4 |
| 1036 | 1.3 | 1.0 | 4.8 | 4.6 | 348 | 6.19 | 1.21 | 0.60 | 0.125 | 1.10 | 9.3 |
| 1037 | 0.0 | 0.2 | 5.9 | 6.3 | 40 | 1.74 | 0.56 | 0.46 | 0.019 | 0.86 | 2.5 |
| 1037 | 0.0 | 0.2 | 5.1 | 5.3 | 29 | 1.74 | 0.58 | 0.46 | 0.024 | 0.83 | 2.5 |
| 1038 | 1.3 | 1.3 | 3.5 | 3.2 | 37 | 2.08 | 0.23 | 0.36 | 0.013 | 1.77 | 3.2 |
| 1038 | 1.4 | 1.6 | 4.1 | 3.7 | 45 | 2.16 | 0.41 | 0.38 | 0.034 | 1.82 | 3.8 |
| 1040 | 1.0 | 0.8 | 6.0 | 6.0 | 60 | 1.19 | 0.65 | 0.32 | 0.024 | 1.09 | 1.9 |
| 1040 | 0.7 | 0.7 | 5.6 | 5.8 | 55 | 1.19 | 0.65 | 0.31 | 0.027 | 1.10 | 1.9 |
| 1041 | 0.8 | 1.0 | 6.2 | 6.5 | 67 | 1.57 | 0.54 | 0.33 | 0.036 | 1.06 | 1.9 |
| 1041 | 1.1 | 1.0 | 6.6 | 6.6 | 71 | 1.49 | 0.52 | 0.33 | 0.030 | 1.02 | 2.5 |
| 1042 | 1.5 | 1.4 | 5.7 | 5.7 | 51 | 1.56 | 0.59 | 0.35 | 0.035 | 0.94 | 1.9 |
| 1042 | 0.2 | 0.1 | 5.6 | 5.9 | 70 | 1.57 | 0.56 | 0.34 | 0.035 | 0.92 | 1.9 |
| 1043 | 0.9 | 0.8 | 5.6 | 5.6 | 72 | 1.75 | 0.53 | 0.40 | 0.032 | 1.00 | 1.3 |
| 1043 | 0.6 | 0.5 | 5.1 | 5.4 | 252 | 1.43 | 0.59 | 0.34 | 0.180 | 0.67 | 2.5 |
| 1044 | 0.0 | 0.0 | 5.6 | 5.4 | 50 | 1.64 | 0.74 | 0.30 | 0.015 | 1.13 | 1.3 |
| 1044 | 0.0 | 0.0 | 5.5 | 5.6 | 30 | 1.64 | 0.70 | 0.29 | 0.014 | 1.07 | 1.3 |
| 1045 | 17.1 | 17.4 | 5.7 | 5.7 | 96 | 1.33 | 0.24 | 0.33 | 0.053 | 10.95 | 2.5 |
| 1045 | 17.4 | 17.1 | 5.9 | 5.7 | 138 | 1.41 | 0.65 | 0.34 | 0.050 | 10.93 | 5.0 |
| 1046 | 1.2 | 1.1 | 6.2 | 5.8 | 91 | 1.98 | 0.46 | 0.32 | 0.030 | 1.18 | 3.8 |
| 1046 | 1.4 | 1.3 | 4.8 | 4.8 | 376 | 4.01 | 0.68 | 0.36 | 0.105 | 0.96 | 8.7 |
| 1047 | 0.0 | 0.0 | 4.2 | 3.8 | 25 | 0.89 | 0.48 | 0.19 | 0.040 | 0.99 | 1.9 |
| 1047 | 0.0 | 0.0 | 3.8 | 3.8 | 36 | 0.94 | 0.48 | 0.19 | 0.033 | 0.98 | 1.9 |
| 1048 | 0.1 | 0.3 | 6.3 | 6.4 | 67 | 1.35 | 0.43 | 0.36 | 0.031 | 1.19 | 3.2 |
| 1048 | 0.0 | 0.1 | 6.5 | 6.1 | 166 | 1.33 | 0.42 | 0.34 | 0.034 | 1.19 | 3.2 |
| 1069 | 1.6 | 1.7 | 5.5 | 5.1 | 0 | 1.38 | 0.54 | 0.49 | 0.028 | 1.91 | 1.9 |
| 1069 | 1.2 | 1.4 | 4.2 | 3.8 | 17 | 1.75 | 0.50 | 0.54 | 0.375 | 1.81 | 2.5 |
| 1070 | 0.9 | 0.8 | 4.6 | 4.3 | 12 | 1.64 | 0.41 | 0.21 | 0.016 | 1.75 | 1.9 |
| 1070 | 0.1 | 0.2 | 4.6 | 4.8 | 13 | 1.65 | 0.40 | 0.22 | 0.020 | 1.76 | 1.9 |
| 1071 | 0.3 | 0.5 | 5.2 | 5.4 | 0 | 1.75 | 0.38 | 0.81 | 0.049 | 1.10 | 1.6 |
| 1071 | 1.1 | 1.0 | 5.3 | 5.0 | 1 | 1.75 | 0.39 | 0.81 | 0.042 | 1.11 | 1.6 |
| 1072 | 3.2 | 2.9 | 4.8 | 5.3 | 160 | 1.09 | 0.48 | 0.25 | 0.024 | 1.74 | 7.4 |
| 1072 | 1.6 | 1.9 | 4.3 | 4.2 | 181 | 1.33 | 0.51 | 0.25 | 0.010 | 1.71 | 7.4 |
| 1073 | 0.9 | 0.9 | 5.8 | 5.0 | 25 | 1.26 | 0.27 | 0.39 | 0.020 | 1.68 | 3.2 |
| 1073 | 1.8 | 1.8 | 4.8 | 4.6 | 63 | 1.25 | 0.27 | 0.40 | 0.015 | 1.69 | 3.2 |
| 1074 | 0.5 | 0.8 | 5.4 | 4.0 | 16 | 1.19 | 0.45 | 0.56 | 0.017 | 1.95 | 2.2 |
| 1074 | 0.9 | 0.8 | 4.8 | 5.3 | 17 | 1.39 | 0.48 | 0.57 | 0.080 | 1.92 | 2.9 |
| 1075 | 1.2 | 1.0 | 6.0 | 5.3 | 36 | 2.21 | 0.86 | 0.51 | 0.055 | 1.98 | 1.9 |
| 1075 | 3.5 | 3.5 | 5.6 | 5.7 | 73 | 2.27 | 0.85 | 0.52 | 0.041 | 1.95 | 2.2 |
| 1076 | 10.0 | 9.8 | 4.8 | 4.3 | 137 | 1.26 | 0.51 | 0.51 | 0.078 | 5.56 | 6.2 |
| 1076 | 9.0 | 8.7 | 4.1 | 3.9 | 55 | 1.47 | 0.42 | 0.48 | 0.054 | 5.71 | 8.4 |
| 1077 | 2.5 | 2.2 | 5.8 | 5.6 | 10 | 1.73 | 0.47 | 0.40 | 0.024 | 1.44 | 1.9 |
| 1077 | 0.9 | 1.1 | 5.8 | 5.7 | 23 | 1.23 | 0.47 | 0.40 | 0.020 | 1.44 | 1.9 |
| 1078 | 1.3 | 1.4 | 3.6 | 3.4 | 33 | 1.91 | 0.44 | 0.32 | 0.017 | 1.92 | 3.8 |
| 1078 | 1.0 | 0.9 | 4.1 | 3.7 | 23 | 1.95 | 0.44 | 0.31 | 0.020 | 1.92 | 3.5 |
| 1079 | 15.0 | 14.7 | 6.2 | 6.0 | 15 | 5.75 | 4.99 | 1.58 | 0.028 | 7.95 | 1.9 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1079 | 14.9 | 14.9 | 6.0 | 5.9 | 21 | 5.85 | 5.00 | 1.59 | 0.090 | 7.86 | 1.9 |
| 1080 | 5.9 | 5.6 | 4.6 | 4.3 | 41 | 1.40 | 0.52 | 0.55 | 0.030 | 3.14 | 5.0 |
| 1080 | 4.4 | 3.8 | 4.3 | 4.3 | 113 | 1.99 | 0.57 | 0.64 | 0.077 | 2.38 | 10.8 |
| 1081 | 1.5 | 1.4 | 3.8 | 3.5 | 11 | 3.20 | 0.49 | 0.35 | 0.009 | 2.08 | 1.9 |
| 1081 | 1.0 | 1.0 | 3.6 | 3.5 | 16 | 3.21 | 0.48 | 0.34 | 0.011 | 2.05 | 1.9 |
| 1082 | 2.0 | 2.0 | 6.3 | 5.9 | 2 | 1.16 | 0.40 | 0.55 | 0.034 | 1.76 | 1.3 |
| 1082 | 1.1 | 1.1 | 3.6 | 3.5 | 23 | 1.17 | 0.36 | 0.55 | 0.117 | 1.69 | 1.6 |
| 1083 | 11.3 | 11.6 | 4.1 | 4.1 | 18 | 2.00 | 0.47 | 0.45 | 0.024 | 6.37 | 5.3 |
| 1083 | 12.5 | 12.7 | 3.1 | 2.9 | 237 | 2.81 | 0.97 | 0.60 | 0.054 | 7.89 | 10.2 |
| 1084 | 1.1 | 1.1 | 5.7 | 5.6 | 45 | 1.05 | 0.17 | 0.35 | 0.024 | 1.42 | 2.9 |
| 1084 | 1.8 | 2.0 | 5.5 | 5.6 | 87 | 1.25 | 0.25 | 0.38 | 0.026 | 1.44 | 5.9 |
| 1085 | 1.6 | 1.5 | 3.9 | 3.9 | 23 | 2.45 | 0.46 | 0.49 | 0.026 | 1.70 | 3.5 |
| 1085 | 0.8 | 0.7 | 2.7 | 2.1 | 85 | 4.41 | 0.84 | 0.57 | 0.133 | 1.82 | 5.9 |
| 1086 | 0.7 | 0.5 | 6.1 | 6.2 | 19 | 1.60 | 0.23 | 0.33 | 0.012 | 0.74 | 1.9 |
| 1086 | 1.3 | 1.0 | 6.0 | 6.1 | 25 | 1.65 | 0.24 | 0.33 | 0.014 | 0.74 | 1.6 |
| 1087 | 2.0 | 1.8 | 5.0 | 4.8 | 47 | 0.83 | 0.32 | 0.40 | 0.032 | 1.71 | 2.5 |
| 1087 | 2.6 | 2.2 | 4.1 | 3.6 | 251 | 1.54 | 0.40 | 0.40 | 0.080 | 1.69 | 5.6 |
| 1088 | 0.3 | 0.4 | 4.3 | 4.5 | 4 | 2.47 | 0.41 | 0.48 | 0.027 | 1.62 | 3.8 |
| 1088 | 1.9 | 1.9 | 4.2 | 4.1 | 40 | 6.55 | 1.14 | 0.58 | 0.144 | 1.59 | 5.0 |
| 1191 | 6.5 | 7.2 | 8.3 | 8.6 | 98 | 6.60 | 1.21 | 1.88 | 0.075 | 3.83 | 1.3 |
| 1192 | 10.8 | 10.6 | 5.9 | 5.7 | 63 | 3.84 | 1.44 | 1.39 | 0.055 | 8.01 | 2.5 |
| 1250 | . | . | . | . | . | 0.91 | 0.13 | 0.23 | 0.058 | 0.49 | 1.6 |
| 1250 | . | . | . | . | . | 0.91 | 0.14 | 0.22 | 0.058 | 0.50 | 1.3 |
| 1251 | . | . | . | . | 146 | 0.32 | 0.19 | 0.07 | 0.031 | 0.24 | 3.2 |
| 1251 | . | . | . | . | 132 | 0.28 | 0.18 | 0.06 | 0.031 | 0.24 | . |
| 1252 | . | . | . | . | 90 | 1.15 | 0.70 | 0.22 | 0.006 | 1.16 | . |
| 1252 | . | . | . | . | 83 | 1.40 | 0.86 | 0.28 | 0.010 | 1.35 | . |
| 1253 | . | . | . | . | 172 | 1.32 | 0.23 | 0.28 | 0.033 | 0.63 | 1.9 |
| 1253 | . | . | . | . | 115 | 1.39 | 0.24 | 0.29 | 0.040 | 0.60 | . |
| 1254 | . | . | . | . | 138 | 0.92 | 0.19 | 0.18 | 0.053 | 0.52 | 2.9 |
| 1254 | . | . | . | . | 200 | 0.98 | 0.25 | 0.19 | 0.071 | 0.52 | 3.8 |

USFWS ACID RAIN SENSITIVITY PROJECT
STATE OF RHODE ISLAND

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | HYDRO. | BED ROCK | SOIL TYPE | DISTR. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1103 | CARBUNCLE PD | 71080 | 414158 | 714128 | 176 | 14 | 1 | 6 | 1 | 5 | 1 | 4.3 | 1524 |
| 1104 | DEEP PD | 71080 | 412326 | 713946 | 16 | 4 | 1 | 6 | 1 | 3 | 2 | 4.3 | 1524 |
| 1105 | ELL POND | 71080 | 413000 | 714628 | 79 | 3 | 1 | 6 | 1 | 5 | 1 | 4.3 | 1524 |
| 1106 | LONG PD | 71080 | 413000 | 714619 | 79 | 8 | 1 | 5 | 1 | 3 | 3 | 4.3 | 1524 |
| 1107 | SUCKER PD | 61080 | 415613 | 714000 | 142 | 23 | 1 | 6 | 2 | 4 | 3 | 4.3 | 1524 |
| 1144 | CARR PD | 81280 | 413909 | 713318 | 110 | 33 | 1 | 6 | 1 | 5 | 2 | 4.3 | 1524 |
| 1145 | WHITE PD | 91280 | 412453 | 713243 | 30 | 9 | 1 | 6 | 1 | 3 | 2 | 4.3 | 1524 |
| 1146 | WILBUR PD | 121280 | 415550 | 714543 | 189 | 9 | 1 | 5 | 1 | 4 | 2 | 4.3 | 1524 |

BEST AVAILABLE COPY

| WATER CODE | DEPTH (M) | TEMP (C) | PH | PH | ALK (F,F,P) (UEQ/L) | ALK (F,F,P) (UEQ/L) | ALK (I,P) (UEQ/L) | ALK (I,P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1103 | 0 | 15 | 6.35 | 6.15 | 83 | 83 | 58 | 58 | 67 | 33 | 20 | 20 |
| 1103 | 6 | 15 | 6.10 | 6.00 | 99 | 100 | 73 | 76 | 67 | 37 | 40 | 40 |
| 1104 | 0 | 16 | 5.95 | 5.70 | 69 | 63 | 22 | 18 | 60 | 33 | 10 | 10 |
| 1104 | 7 | 14 | 5.75 | 5.75 | 99 | 99 | 72 | 70 | 60 | 35 | 60 | 60 |
| 1105 | 0 | 15 | 4.25 | 4.35 | 0 | 0 | -45 | -36 | 38 | 37 | 100 | 100 |
| 1105 | 7 | 15 | 4.25 | 4.30 | 0 | 0 | -47 | -46 | 38 | 37 | 130 | 100 |
| 1106 | 0 | 15 | 4.35 | 4.40 | 0 | 0 | -35 | -27 | 35 | 37 | 60 | 50 |
| 1106 | 6 | 11 | 5.35 | 5.40 | 73 | 77 | 45 | 51 | 23 | 20 | 130 | 130 |
| 1107 | 0 | 17 | 6.80 | 6.80 | 195 | 197 | 166 | 163 | 73 | 22 | 20 | 20 |
| 1107 | 6 | 16 | 6.75 | 6.80 | 194 | 196 | 163 | 162 | 75 | 23 | 20 | 20 |
| 1144 | 0 | 5 | 4.70 | 4.78 | 17 | 17 | -16 | -15 | 37 | 36 | 0 | 0 |
| 1144 | 2 | 5 | 4.65 | 4.75 | 6 | 18 | -15 | -16 | 36 | 33 | 0 | 0 |
| 1145 | 0 | 5 | 4.35 | 4.44 | 0 | 0 | -33 | -31 | 68 | 66 | 0 | 0 |
| 1145 | 8 | 4 | 4.40 | 4.44 | 0 | 0 | -28 | -32 | 68 | 63 | 0 | 0 |
| 1146 | 0 | 1 | 3.95 | 4.01 | 0 | 0 | -84 | -96 | 72 | 66 | 150 | 150 |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | [illegible] (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1103 | 7.2 | 7.3 | 7.7 | 7.2 | 19 | 2.08 | 0.83 | 0.66 | 0.030 | 4.45 | 2.5 |
| 1103 | 7.7 | 7.7 | 7.3 | 6.8 | 47 | 2.12 | 0.86 | 0.65 | 0.028 | 4.60 | 3.3 |
| 1104 | 7.5 | 6.6 | 6.6 | 6.5 | 33 | 1.35 | 0.53 | 0.61 | 0.067 | 4.71 | 1.3 |
| 1104 | 6.1 | 6.3 | 5.8 | 5.6 | 156 | 2.00 | 0.69 | 0.61 | 0.087 | 3.93 | 3.0 |
| 1105 | 5.3 | 5.6 | 5.0 | 4.8 | 163 | 0.67 | 0.47 | 0.33 | 0.091 | 2.65 | 7.5 |
| 1105 | 5.6 | 5.0 | 4.6 | 4.1 | 187 | 0.71 | 0.46 | 0.32 | 0.022 | 2.64 | 7.4 |
| 1106 | 4.1 | 3.8 | 6.0 | 5.5 | 170 | 0.68 | 0.44 | 0.30 | 0.043 | 2.17 | 4.7 |
| 1106 | 4.9 | 5.0 | 4.5 | 4.3 | 250 | 0.74 | 0.54 | 0.38 | 0.076 | 4.50 | 7.4 |
| 1107 | 13.3 | 13.0 | 6.0 | 5.8 | 50 | 3.27 | 1.78 | 1.08 | 0.039 | 7.76 | 2.5 |
| 1107 | 13.6 | 17.8 | 5.5 | 5.6 | 60 | 3.26 | 1.30 | 1.06 | 0.043 | 7.37 | 2.5 |
| 1144 | 3.9 | 4.1 | 7.0 | 6.1 | 381 | 1.06 | 0.43 | 0.36 | 0.089 | 2.50 | 1.3 |
| 1144 | 3.8 | 3.8 | 5.7 | 6.2 | 381 | 1.08 | 0.43 | 0.36 | 0.091 | 3.60 | 1.3 |
| 1145 | 7.4 | 7.6 | 6.1 | 5.7 | 579 | 0.91 | 0.59 | 0.61 | 0.065 | 3.36 | 1.3 |
| 1145 | 6.8 | 6.3 | 5.9 | 6.1 | 185 | 0.91 | 0.80 | 0.60 | 0.063 | 4.45 | 1.3 |
| 1146 | 3.3 | 3.5 | 7.2 | 6.1 | 357 | 1.30 | 0.46 | 0.36 | 0.061 | 2.30 | 13.5 |

USFWS ACID RAIN SENSITIVITY PROJECT
STATE OF VERMONT

| WATER CODE | NAME | DATE DAY-MON-YR | LATITUDE DEG-MIN-SEC | LONG. | ELEV (M) | AREA (HA) | TYPE | WSHED. | BED ROCK | SOIL TYPE | DIST. | PRECIP. PH | ANNUAL PRECIP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1001 | LYE BROOK MEADOWS ST | 240780 | 430600 | 730145 | 786 | 1 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1002 | BRANCH PD | 240780 | 430443 | 730145 | 807 | 17 | 1 | 5 | 2 | 5 | 1 | 4.3 | 1118 |
| 1003 | NOYES PD | 220780 | 441307 | 721816 | 518 | 17 | 1 | 5 | 1 | 5 | 1 | 4.3 | 914 |
| 1004 | BEEBE PD | 240780 | 430326 | 730145 | 716 | 2 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1005 | BOURN PD | 230780 | 430747 | 730030 | 778 | 16 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1006 | SOUTH FORK STREAM | 240780 | 430143 | 730448 | 657 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1007 | STERLING PD | 250780 | 443411 | 724447 | 737 | 1 | 1 | 6 | 2 | 5 | 1 | 4.3 | 914 |
| 1008 | STRATTON PD | 230780 | 430747 | 725830 | 787 | 71 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1009 | WHEELER PD | 210780 | 444111 | 720477 | 677 | 1 | 1 | 6 | 1 | 5 | 1 | 4.3 | 1118 |
| 1010 | KETTLE PD | 220780 | 441744 | 721845 | 677 | 96 | 1 | 6 | 1 | 5 | 2 | 4.3 | 914 |
| 1011 | OSMORE PD | 220780 | 441816 | 721430 | 677 | 17 | 1 | 6 | 1 | 5 | 1 | 4.3 | 914 |
| 1014 | BALL MTN BROOK HDWS. | 60880 | 430913 | 725431 | 555 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1015 | GREENDALE BROOK HDWS | 70880 | 432019 | 724936 | 610 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1016 | ROCK RIVER HDWS. | 70880 | 425933 | 724427 | 677 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1017 | WARDSBORO BROOK HDWS | 60880 | 430159 | 725604 | 549 | 2 | 2 | 1 | 2 | 5 | 1 | 4.3 | 1118 |
| 1018 | WEST RIVER HDWS. | 70880 | 431707 | 724807 | 610 | 2 | 2 | 1 | 2 | 5 | 2 | 4.3 | 1118 |
| 1019 | WINHALL RIVER HDWS. | 50880 | 430747 | 725900 | 905 | 2 | 2 | 2 | 2 | 5 | 1 | 4.3 | 1118 |
| 1024 | FORRESTER PD | 60880 | 430155 | 725146 | 549 | 1 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |
| 1039 | BAKER PD | 91080 | 444428 | 721615 | 395 | 17 | 1 | 5 | 3 | 5 | 4 | 4.3 | 1118 |
| 1090 | BALD HILL PD | 91080 | 444530 | 715857 | 518 | 45 | 1 | 5 | 3 | 5 | 3 | 4.3 | 1118 |
| 1091 | COW MOUNTAIN PD | 101080 | 443345 | 714737 | 575 | 1 | 1 | 6 | 2 | 5 | 1 | 4.3 | 914 |
| 1092 | CUT PD | 81080 | 444056 | 723119 | 366 | 2 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1093 | HARDWOOD PD | 91080 | 442759 | 723000 | 518 | 17 | 1 | 6 | 2 | 5 | 2 | 4.3 | 914 |
| 1094 | ROUNDS PD | 71080 | 445946 | 721006 | 91 | 2 | 1 | 6 | 6 | 5 | 6 | 4.3 | 914 |
| 1095 | RICHMOND PD OUTLET | 81080 | 442919 | 725458 | 183 | 1 | 2 | 1 | 2 | 5 | 2 | 4.3 | 914 |
| 1111 | BEAVER PD | 281080 | 440345 | 724360 | 518 | 1 | 1 | 6 | 2 | 5 | 3 | 4.3 | 914 |
| 1112 | CHOATE PD | 281080 | 434937 | 731608 | 244 | 10 | 1 | 6 | 6 | 5 | 3 | 4.3 | 1118 |
| 1113 | COITS PD | 281080 | 442647 | 722019 | 396 | 14 | 1 | 6 | 3 | 5 | 1 | 4.3 | 914 |
| 1114 | CRANBERRY MEADOW PD | 281080 | 442519 | 723755 | 335 | 10 | 1 | 5 | 3 | 5 | 3 | 4.3 | 914 |
| 1115 | HALFMOON PD | 291080 | 434950 | 731370 | 152 | 14 | 1 | 5 | 2 | 5 | 3 | 4.3 | 1118 |
| 1116 | HORN OF THE MOON PD | 281080 | 441933 | 723307 | 366 | 2 | 1 | 6 | 2 | 5 | 3 | 4.3 | 914 |
| 1117 | HOUGH PD | 291080 | 434708 | 731101 | 244 | 7 | 1 | 6 | 6 | 5 | 3 | 4.3 | 1118 |
| 1118 | JOHNSON PD | 291080 | 434606 | 731357 | 122 | 3 | 1 | 6 | 6 | 5 | 3 | 4.3 | 1118 |
| 1119 | LAKE MITCHELL | 311080 | 434500 | 722420 | 244 | 10 | 1 | 5 | 2 | 5 | 3 | 4.3 | 1118 |
| 1120 | LAKOTA LAKE | 301080 | 434107 | 723307 | 549 | 10 | 1 | 6 | 3 | 5 | 2 | 4.3 | 1118 |
| 1121 | MUDDY LAKE | 311080 | 440636 | 721015 | 326 | 1 | 1 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1122 | NORTH PD | 301080 | 440756 | 721735 | 457 | 3 | 1 | 5 | 3 | 5 | 1 | 4.3 | 914 |
| 1123 | SUGAR HOLLOW PD | 291080 | 434516 | 730162 | 326 | 14 | 1 | 6 | 3 | 5 | 1 | 4.3 | 1118 |
| 1124 | TINY PD | 301080 | 432719 | 724357 | 518 | 6 | 1 | 6 | 3 | 5 | 1 | 4.3 | 1118 |
| 1125 | TWIN PONDS-EAST | 301080 | 440307 | 723507 | 396 | 6 | 1 | 6 | 3 | 5 | 3 | 4.3 | 914 |
| 1126 | WALLINGFORD PD | 291080 | 432507 | 725441 | 640 | 44 | 1 | 5 | 2 | 5 | 1 | 4.3 | 1118 |
| 1161 | WESTFORD PD | 81080 | 443537 | 730359 | 244 | 6 | 1 | 6 | 3 | 3 | 2 | 4.3 | 914 |
| 1182 | KINGS HILL PD | 81080 | 444373 | 724715 | 335 | 7 | 1 | 6 | 3 | 5 | 3 | 4.3 | 914 |
| 1183 | BALL MTN BRK MOUTH | 60880 | 430545 | 724650 | 213 | 5 | 3 | 6 | 3 | 5 | 3 | 4.3 | 1113 |
| 1184 | GREENDALE BRK MOUTH | 70880 | 431901 | 724736 | 396 | 3 | 2 | 3 | 3 | 5 | 3 | 4.3 | 1118 |
| 1185 | ROCK RIVER MOUTH | 70880 | 425726 | 724203 | 91 | 5 | 3 | 6 | 3 | 5 | 3 | 4.3 | 1133 |
| 1186 | WARDSBORO BRK MOUTH | 60880 | 430613 | 724416 | 152 | 5 | 3 | 6 | 2 | 5 | 2 | 4.3 | 1118 |
| 1187 | WEST RIVER | 70880 | 431725 | 724744 | 396 | 10 | 3 | 6 | 3 | 5 | 3 | 4.3 | 1118 |
| 1188 | WINHALL RIVER MOUTH | 60880 | 430979 | 724744 | 226 | 5 | 3 | 6 | 3 | 5 | 3 | 4.3 | 1118 |
| 1255 | GRIFFITH LAKE | 271079 | 431811 | 725790 | 800 | 6 | 1 | 6 | 2 | 5 | 1 | 4.3 | 1118 |

| WATER CODE | DEPTH (M) | TEMP (C) | PH | PH | ALK (F.E.P) (UEQ/L) | ALK (F.E.P) (UEQ/L) | ALK (I.P) (UEQ/L) | ALK (I.P) (UEQ/L) | COND (US/CM) | COND (US/CM) | COLOR (UNITS) | COLOR (UNITS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1001 | 0 | 23 | 4.15 | . | . | . | -79 | . | 33 | . | 260 | . |
| 1002 | 0 | 23 | 4.65 | . | 8 | . | -21 | . | 18 | . | 20 | . |
| 1002 | 9 | 19 | 4.55 | . | 29 | . | 1 | . | 17 | . | 40 | . |
| 1003 | 0 | 24 | 7.70 | . | 435 | . | 389 | . | 51 | . | 30 | . |
| 1003 | 3 | 23 | 7.55 | . | 444 | . | 396 | . | 50 | . | 40 | . |
| 1004 | 0 | 24 | 5.05 | . | 38 | . | -2 | . | 22 | . | 50 | . |
| 1004 | 3 | 19 | 4.55 | . | 29 | . | -3 | . | 18 | . | 40 | . |
| 1005 | 0 | 23 | 5.00 | . | 27 | . | -6 | . | 14 | . | 30 | . |
| 1005 | 2 | 23 | 5.15 | . | 30 | . | -4 | . | 15 | . | 30 | . |
| 1006 | 0 | 17 | 5.50 | . | 36 | . | 7 | . | 19 | . | 0 | . |
| 1007 | 0 | 21 | 6.45 | . | 81 | . | 48 | . | 20 | . | 50 | . |
| 1007 | 5 | 17 | 5.75 | . | 100 | . | 66 | . | 21 | . | 60 | . |
| 1008 | 0 | 22 | 6.05 | . | 43 | . | 11 | . | 16 | . | 20 | . |
| 1008 | 3 | 22 | 6.20 | . | 43 | . | 11 | . | 14 | . | 20 | . |
| 1009 | 0 | 26 | 7.45 | . | 301 | . | 257 | . | 38 | . | 10 | . |
| 1009 | 8 | 18 | 6.30 | . | 290 | . | 242 | . | 31 | . | 0 | . |
| 1010 | 0 | 25 | 7.05 | . | 136 | . | 97 | . | 30 | . | 20 | . |
| 1010 | 3 | 25 | 7.05 | . | 136 | . | 96 | . | 29 | . | 10 | . |
| 1011 | 0 | 25 | 7.25 | . | 208 | . | 170 | . | 31 | . | 0 | . |
| 1011 | 2 | 25 | 7.20 | . | 207 | . | 175 | . | 34 | . | 10 | . |
| 1014 | 0 | . | 5.20 | 5.20 | 36 | 32 | 10 | -1 | 31 | 22 | 20 | 20 |
| 1015 | 0 | . | 6.55 | 6.60 | 315 | 312 | 281 | 272 | 41 | 42 | 30 | 30 |
| 1016 | 0 | . | 7.15 | 7.10 | 330 | 320 | 289 | 302 | 52 | 54 | 0 | 0 |
| 1017 | 0 | . | 6.50 | 6.55 | 165 | 167 | 132 | 132 | 30 | 29 | 20 | 20 |
| 1018 | 0 | . | 7.15 | 7.20 | 497 | 487 | 454 | 450 | 110 | 110 | 0 | 0 |
| 1019 | 0 | 23 | 4.50 | 4.90 | 29 | 27 | -8 | -12 | 16 | 22 | 120 | 120 |
| 1024 | 0 | 26 | 5.05 | 5.10 | 38 | 38 | -1 | -2 | 20 | 20 | 20 | 20 |
| 1024 | 2 | 27 | 5.15 | 5.15 | 38 | 38 | 2 | -2 | 20 | 20 | 20 | 20 |
| 1089 | 0 | 10 | 7.56 | 7.32 | 1350 | 1300 | 1282 | 1261 | 150 | 140 | 20 | 20 |
| 1089 | 5 | 10 | 7.54 | 7.35 | 1351 | 1284 | 1315 | 1282 | 140 | 145 | 30 | 30 |
| 1090 | 0 | 12 | 7.68 | 7.25 | 868 | 837 | 850 | 809 | 95 | 90 | 10 | 10 |
| 1090 | 8 | 11 | 7.65 | 7.40 | 858 | 848 | 781 | 821 | 90 | 90 | 10 | 10 |
| 1091 | 0 | 9 | 6.55 | 6.53 | 149 | 160 | 116 | 117 | 24 | 23 | 40 | 40 |
| 1091 | 5 | 8 | 6.55 | 6.55 | 163 | 153 | 120 | 117 | 24 | 24 | 50 | 50 |
| 1092 | 0 | 13 | 6.86 | 6.47 | 159 | 138 | 124 | 107 | 24 | 24 | 10 | 10 |
| 1092 | 12 | 14 | 6.09 | 5.80 | 167 | 146 | 198 | 119 | 26 | 26 | 10 | 10 |
| 1093 | 0 | 11 | 5.84 | 5.66 | 51 | 33 | 18 | 13 | 24 | 24 | 30 | 30 |
| 1093 | 2 | 10 | 5.84 | 5.57 | 50 | 36 | 18 | 14 | 20 | 22 | 30 | 30 |
| 1094 | 0 | 15 | 8.21 | 7.98 | 2821 | 2754 | 2767 | 2726 | 300 | 300 | 10 | 10 |
| 1094 | 5 | 15 | 8.15 | 7.72 | 2878 | 2788 | 2836 | 2735 | 300 | 235 | 10 | 10 |
| 1095 | 0 |  | 6.80 | 6.48 | 275 | 254 | 235 | 226 | 35 | 36 | 50 | 50 |
| 1111 | 0 | 5 | 5.79 | 5.00 | 55 | 23 | 14 | -33 | 25 | 25 | 20 | 20 |
| 1111 | 2 | 5 | 5.85 | 5.55 | 57 | 40 | 17 | 15 | 19 | 18 | 20 | 20 |
| 1112 | 0 | 6 | 7.55 | 7.73 | 735 | 870 | 701 | 633 | 110 | 120 | 20 | 10 |
| 1112 | 3 | 6 | 7.75 | 7.55 | 905 | 845 | 870 | 812 | 100 | 120 | 20 | 10 |
| 1113 | 0 | 4 | 7.80 | 7.70 | 1161 | 1121 | 1124 | 1069 | 110 | 110 | 10 | 10 |
| 1113 | 2 | 4 | 7.71 | 7.60 | 1184 | 1118 | 1141 | 1080 | 110 | 110 | 10 | 10 |
| 1114 | 0 | 7 | 7.25 | 7.35 | 1036 | 967 | 1005 | 905 | 110 | 100 | 20 | 20 |
| 1114 | 6 | 7 | 7.15 | 7.35 | 1028 | 982 | 1031 | 944 | 110 | 105 | 20 | 20 |
| 1115 | 0 | 7 | 7.75 | 7.65 | 1302 | 1176 | 1268 | 1129 | 120 | 130 | 10 | 10 |
| 1115 | 2 | 7 | 7.65 | 7.66 | 1313 | 1149 | 1283 | 1132 | 120 | 140 | 10 | 10 |
| 1116 | 0 | 6 | 8.00 | 7.95 | 2339 | 2281 | 2305 | 2241 | 200 | 210 | 20 | 20 |
| 1116 | 2 | 5 | 7.75 | 7.95 | 2339 | 2248 | 2315 | 2203 | 220 | 210 | 20 | 20 |
| 1117 | 0 | 8 | 7.62 | 7.72 | 2047 | 2000 | 2001 | 1943 | 220 | 230 | 20 | 20 |

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| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1117 | 5 | 8 | 7.56 | 7.75 | 2035 | 2011 | 1998 | 1976 | 220 | 220 | 20 | 20 |
| 1118 | 0 | 5 | 7.02 | 6.95 | 307 | 307 | 272 | 273 | 45 | 43 | 40 | 40 |
| 1118 | 2 | 7 | 7.05 | 6.98 | 314 | 297 | 271 | 259 | 44 | 44 | 40 | 40 |
| 1119 | 0 | 6 | 7.85 | 7.95 | 1871 | 1761 | 1827 | 1740 | 210 | 210 | 10 | 10 |
| 1119 | 3 | 6 | 7.80 | 7.95 | 1863 | 1810 | 1939 | 1723 | 210 | 210 | 10 | 10 |
| 1120 | 0 | 4 | 7.08 | 7.15 | 231 | 254 | 197 | 219 | 36 | 36 | 30 | 20 |
| 1120 | 3 | 4 | 7.05 | 7.05 | 223 | 247 | 186 | 216 | 33 | 32 | 30 | 20 |
| 1121 | 0 | 6 | 7.55 | 7.35 | 634 | 614 | 594 | 578 | 99 | 98 | 13 | 20 |
| 1121 | 1 | 6 | 7.60 | 7.55 | 683 | 614 | 644 | 582 | 80 | 95 | 10 | 20 |
| 1122 | 0 | 4 | 7.55 | 7.90 | 1686 | 1606 | 1661 | 1585 | 160 | 160 | 20 | 20 |
| 1122 | 2 | 5 | 7.85 | 7.85 | 1651 | 1584 | 1615 | 1558 | 160 | 160 | 20 | 20 |
| 1123 | 0 | 7 | 7.65 | 7.70 | 1044 | 925 | 1010 | 880 | 110 | 120 | 20 | 20 |
| 1123 | 1 | 7 | 7.65 | 7.70 | 1031 | 947 | 1001 | 897 | 110 | 120 | 30 | 30 |
| 1124 | 0 | 5 | 7.00 | 7.50 | 262 | 271 | 226 | 233 | 35 | 36 | 40 | 40 |
| 1124 | 3 | 5 | 6.95 | 6.90 | 269 | 269 | 235 | 237 | 35 | 35 | 40 | 40 |
| 1125 | 0 | 6 | 8.10 | 8.05 | 2898 | 2771 | 2866 | 2733 | 270 | 26 | 20 | 20 |
| 1125 | 8 | 7 | 7.62 | 7.65 | 2307 | 2358 | 2270 | 2309 | 270 | 260 | 10 | 10 |
| 1126 | 0 | 4 | 6.65 | 6.52 | 120 | 117 | 91 | 83 | 28 | 28 | 20 | 20 |
| 1126 | 2 | 4 | 6.60 | 6.49 | 108 | 127 | 77 | 94 | 28 | 26 | 30 | 20 |
| 1161 | 0 | 13 | 7.46 | 7.18 | 531 | 520 | 497 | 491 | 70 | 62 | 10 | 10 |
| 1161 | 6 | 14 | 6.95 | 6.64 | 532 | 524 | 495 | 496 | 62 | 60 | 10 | 10 |
| 1182 | 0 | 12 | 5.33 | 5.03 | 38 | 21 | 3 | -4 | 20 | 20 | 40 | 40 |
| 1182 | 3 | 13 | 5.35 | 5.16 | 42 | 32 | 4 | 5 | 20 | 21 | 40 | 40 |
| 1183 | 0 | . | 6.85 | 6.75 | 97 | 100 | 63 | 62 | 32 | 32 | 20 | 20 |
| 1184 | 0 | . | 7.45 | 7.45 | 444 | 438 | 412 | 402 | 51 | 53 | 10 | 10 |
| 1185 | 0 | . | 7.65 | 7.55 | 452 | 459 | 421 | 426 | 70 | 70 | 10 | 10 |
| 1186 | 0 | . | 7.20 | 7.20 | 229 | 233 | 195 | 198 | 50 | 50 | 20 | 20 |
| 1187 | 0 | . | 7.15 | 7.15 | 362 | 394 | 343 | 361 | 84 | 86 | 10 | 10 |
| 1188 | 0 | . | 6.85 | 6.85 | 129 | 129 | 92 | 90 | 33 | 33 | 60 | 60 |
| 1255 | 1 | 6 | 5.85 | . | 47 | . | 29 | . | 22 | . | 40 | . |
| 1255 | 5 | 6 | 5.80 | . | 41 | . | 28 | . | 22 | . | 50 | . |

| WATER CODE | CHLORIDE (PPM) | CHLORIDE (PPM) | SULFATE (PPM) | SULFATE (PPM) | ALUMINUM (PPB) | CALCIUM (PPM) | POTASSIUM (PPM) | MAGNESIUM (PPM) | MANGANESE (PPM) | SODIUM (PPM) | TOC (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1001 | 2.4 | 2.7 | 2.4 | 2.4 | 385 | 3.90 | 0.30 | 0.23 | 0.026 | 0.83 | 17.3 |
| 1002 | 1.1 | 1.0 | 5.0 | 5.2 | 182 | 0.93 | 0.54 | 0.21 | 0.050 | 0.70 | 2.5 |
| 1002 | 0.0 | 0.0 | 5.0 | 5.0 | 245 | . | . | . | . | 0.68 | 3.8 |
| 1003 | 0.6 | 0.5 | 5.3 | 5.2 | 65 | 6.74 | 0.65 | 0.78 | 0.055 | 1.43 | 3.2 |
| 1003 | 0.1 | 0.0 | 5.0 | 5.0 | 96 | 6.79 | 0.61 | 0.79 | 0.062 | 1.35 | 3.8 |
| 1004 | 0.9 | 1.1 | 5.0 | 5.1 | 271 | 0.94 | 0.53 | 0.35 | 0.042 | 0.89 | 3.9 |
| 1004 | 2.1 | 2.1 | 5.0 | 4.8 | 358 | 0.97 | 0.50 | 0.36 | 0.059 | 0.71 | 3.8 |
| 1005 | 0.3 | 0.2 | 4.8 | 5.1 | 163 | 0.91 | 0.52 | 0.36 | 0.053 | 0.90 | 3.2 |
| 1005 | 0.6 | 0.7 | 4.8 | 5.0 | 254 | 1.02 | 0.53 | 0.38 | 0.065 | 0.66 | 3.2 |
| 1006 | 0.8 | 0.8 | 4.7 | 4.8 | 188 | 1.04 | 0.47 | 0.29 | 0.033 | 1.08 | 1.3 |
| 1007 | 0.2 | 0.3 | 4.8 | 4.8 | 144 | 1.66 | 0.31 | 0.88 | 0.032 | 0.46 | 4.4 |
| 1007 | 1.3 | 1.2 | 4.5 | 4.3 | 324 | 2.05 | 0.32 | 0.89 | 0.156 | 0.25 | 5.0 |
| 1008 | 0.9 | 0.7 | 4.6 | 4.4 | 64 | 1.14 | 0.67 | 0.36 | 0.035 | 0.63 | 2.5 |
| 1008 | 1.3 | 1.2 | 3.9 | 4.0 | 206 | 1.21 | 0.60 | 0.36 | 0.038 | 0.57 | 2.5 |
| 1009 | 0.5 | 0.4 | 5.7 | 5.5 | 108 | 5.25 | 0.48 | 0.77 | 0.031 | 1.17 | 1.9 |
| 1009 | 0.1 | 0.3 | 4.2 | 4.1 | 92 | 5.23 | 0.44 | 0.77 | 0.033 | 1.14 | 1.3 |
| 1010 | 0.9 | 0.7 | 6.0 | 6.1 | 60 | 3.14 | 0.50 | 0.47 | 0.016 | 1.13 | 2.5 |
| 1010 | 0.2 | 0.2 | 5.8 | 5.9 | 48 | 3.09 | 0.49 | 0.47 | 0.015 | 1.13 | 1.9 |
| 1011 | 0.4 | 0.7 | 4.9 | 4.8 | 67 | 3.58 | 0.55 | 0.50 | 0.030 | 1.58 | 1.3 |
| 1011 | 1.2 | 1.0 | 4.9 | 4.8 | 77 | 3.62 | 0.55 | 0.50 | 0.033 | 1.55 | 1.9 |
| 1014 | 0.2 | 0.3 | 6.1 | 5.9 | 343 | 1.57 | 0.44 | 0.39 | 0.040 | 1.06 | 2.5 |
| 1015 | 0.6 | 0.6 | 4.7 | 4.6 | 91 | 4.47 | 0.98 | 1.30 | 0.208 | 1.25 | 3.2 |
| 1016 | 0.6 | 0.5 | 7.9 | 7.7 | 21 | 5.54 | 1.07 | 1.48 | 0.013 | 1.45 | 1.3 |
| 1017 | 0.6 | 0.5 | 5.3 | 5.1 | 74 | 3.03 | 0.64 | 0.78 | 0.091 | 1.14 | 2.5 |
| 1018 | 13.8 | 13.6 | 7.2 | 7.0 | 33 | 10.51 | 1.52 | 2.34 | 0.067 | 7.77 | 1.3 |
| 1019 | 0.8 | 1.0 | 3.4 | 3.2 | 327 | 0.93 | 0.35 | 0.34 | 0.060 | 0.83 | 8.7 |
| 1024 | 1.0 | 0.7 | 4.5 | 4.4 | 135 | 1.11 | 0.56 | 0.18 | 0.074 | 0.78 | 2.5 |
| 1024 | 1.1 | 0.9 | 4.3 | 4.3 | 317 | 1.17 | 0.59 | 0.19 | 0.072 | 0.80 | 2.5 |
| 1089 | 2.2 | 2.1 | 8.9 | 8.1 | 46 | 24.68 | 1.63 | 2.89 | 0.106 | 1.55 | 2.5 |
| 1089 | 1.9 | 2.2 | 5.4 | 5.0 | 59 | 24.51 | 1.62 | 2.86 | 0.125 | 1.54 | 2.5 |
| 1090 | 0.0 | 0.0 | 6.6 | 6.5 | 1 | 12.52 | 0.31 | 0.58 | 0.021 | 0.48 | 1.9 |
| 1090 | 0.3 | 0.4 | 6.5 | 6.5 | 17 | 17.59 | 0.44 | 0.84 | 0.021 | 0.67 | 1.9 |
| 1091 | 0.0 | 0.0 | 6.0 | 5.6 | 85 | 2.70 | 0.52 | 0.81 | 0.036 | 0.85 | 3.8 |
| 1091 | 0.0 | 0.0 | 5.8 | 6.0 | 79 | 2.71 | 0.54 | 0.79 | 0.038 | 0.88 | 4.4 |
| 1092 | 0.0 | 0.0 | 3.5 | 3.6 | 5 | 1.89 | 0.28 | 1.26 | 0.024 | 0.76 | 1.9 |
| 1092 | 0.2 | 0.5 | 5.7 | 5.3 | 5 | 2.04 | 0.28 | 1.29 | 0.068 | 0.34 | 1.9 |
| 1093 | 0.2 | 0.1 | 8.5 | 7.4 | 2 | 1.72 | 0.26 | 0.51 | 0.058 | 0.51 | 3.2 |
| 1093 | 0.4 | 0.3 | 6.1 | 5.9 | 358 | 1.77 | 0.27 | 0.51 | 0.058 | 0.51 | 3.2 |
| 1094 | 8.4 | 8.7 | 9.4 | 9.4 | 0 | 30.78 | 1.33 | 16.44 | 0.035 | 5.01 | 1.9 |
| 1094 | 9.1 | 9.1 | 9.5 | 9.4 | 2 | 30.69 | 1.30 | 16.26 | 0.045 | 4.95 | 1.9 |
| 1095 | 0.0 | 0.0 | 6.9 | 5.9 | 319 | 4.62 | 0.45 | 0.81 | 0.082 | 0.66 | 4.4 |
| 1111 | 0.6 | 0.5 | 7.0 | 5.5 | 55 | 1.55 | 0.16 | 0.32 | 0.034 | 0.46 | 2.5 |
| 1111 | 0.5 | 0.6 | 4.8 | 5.3 | 50 | 1.53 | 0.16 | 0.32 | 0.030 | 0.46 | 2.5 |
| 1112 | 0.0 | 0.0 | 14.1 | 13.4 | 18 | 17.25 | 0.54 | 3.28 | 0.009 | 1.08 | 2.2 |
| 1112 | 0.0 | 0.0 | 14.1 | 14.2 | 13 | 17.33 | 0.55 | 3.30 | 0.013 | 1.07 | 2.2 |
| 1113 | 0.3 | 0.2 | 9.6 | 9.0 | 0 | 23.41 | 0.86 | 1.34 | 0.011 | 0.75 | 1.9 |
| 1113 | 0.0 | 0.2 | 9.1 | 8.8 | 23 | 23.37 | 0.88 | 1.35 | 0.010 | 0.77 | 1.9 |
| 1114 | 0.5 | 0.6 | 7.2 | 6.8 | 0 | 18.68 | 0.34 | 2.17 | 0.064 | 0.75 | 2.5 |
| 1114 | 0.5 | 0.2 | 6.5 | 6.5 | 0 | 18.61 | 0.34 | 2.14 | 0.081 | 0.73 | 2.5 |
| 1115 | 1.9 | 1.8 | 7.7 | 7.5 | 34 | 17.58 | 0.56 | 2.34 | 0.018 | 1.27 | 1.9 |
| 1115 | 2.8 | 2.7 | 7.7 | 7.2 | 0 | 19.30 | 0.53 | 3.37 | 0.007 | 1.34 | 1.9 |
| 1116 | 2.7 | 2.7 | 8.2 | 7.4 | 0 | 38.93 | 0.69 | 4.29 | 0.034 | 1.46 | 2.5 |
| 1116 | 0.8 | 0.7 | 7.8 | 8.3 | 0 | 39.23 | 0.69 | 4.27 | 0.041 | 1.47 | 2.5 |
| 1117 | 1.8 | 1.7 | 16.3 | 17.5 | 7 | 39.19 | 0.48 | 5.07 | 0.136 | 1.75 | 2.5 |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1117 | 0.9 | 0.8 | 15.8 | 16.6 | 2 | 38.60 | 0.48 | 5.08 | 0.136 | 1.72 | 2.5 |
| 1118 | 1.6 | 1.7 | 4.8 | 3.9 | 7 | 4.55 | 0.82 | 1.24 | 0.014 | 1.34 | 3.8 |
| 1118 | 2.8 | 2.8 | 4.6 | 4.5 | 13 | 4.58 | 0.84 | 1.25 | 0.009 | 1.35 | 3.8 |
| 1119 | 6.1 | 6.1 | 8.5 | 8.3 | 10 | 35.77 | 1.84 | 2.17 | 0.088 | 3.05 | 1.9 |
| 1119 | 4.9 | 4.9 | 7.2 | 7.0 | 23 | 35.58 | 1.84 | 2.16 | 0.118 | 3.04 | 1.9 |
| 1120 | 0.0 | 0.0 | 5.9 | 5.3 | 38 | 3.96 | 0.39 | 0.88 | 0.033 | 0.69 | 2.9 |
| 1120 | 0.5 | 0.4 | 5.8 | 5.6 | 45 | 3.90 | 0.34 | 0.84 | 0.036 | 0.65 | 2.9 |
| 1121 | 0.3 | 0.4 | 11.4 | 12.0 | 16 | 14.28 | 0.59 | 1.37 | 0.010 | 1.26 | 2.2 |
| 1121 | 0.4 | 0.6 | 10.5 | 11.0 | 0 | 14.20 | 0.57 | 1.39 | 0.009 | 1.25 | 2.2 |
| 1122 | 1.8 | 1.8 | 5.3 | 4.8 | 8 | 30.46 | 0.19 | 2.04 | 0.034 | 0.79 | 2.5 |
| 1122 | 1.8 | 1.9 | 5.2 | 4.6 | 4 | 30.68 | 0.22 | 2.04 | 0.024 | 0.81 | 2.5 |
| 1123 | 1.2 | 1.1 | 11.8 | 11.8 | 29 | 14.21 | 0.80 | 6.49 | 0.016 | 1.06 | 3.5 |
| 1123 | 0.7 | 0.8 | 11.8 | 11.8 | 46 | 14.07 | 0.76 | 6.48 | 0.015 | 1.02 | 3.2 |
| 1124 | 0.7 | 0.7 | 4.8 | 4.6 | 62 | 3.78 | 0.91 | 1.06 | 0.021 | 0.72 | 3.8 |
| 1124 | 0.7 | 0.7 | 4.8 | 4.8 | 53 | 3.75 | 0.91 | 1.07 | 0.037 | 0.73 | 3.8 |
| 1125 | 0.9 | 0.7 | 7.5 | 7.2 | . | 47.89 | 0.69 | 7.25 | 0.005 | 1.23 | 2.5 |
| 1125 | 0.7 | 0.8 | 6.7 | 6.7 | . | 47.61 | 0.67 | 7.05 | 0.007 | 1.19 | 1.9 |
| 1126 | 15.8 | 18.7 | 8.1 | 7.9 | 47 | 2.46 | 0.69 | 0.71 | 0.010 | 0.65 | 3.5 |
| 1126 | 18.6 | 18.6 | 7.9 | 7.7 | 47 | 2.50 | 0.69 | 0.70 | 0.012 | 0.68 | 2.9 |
| 1161 | 0.6 | 0.7 | 8.1 | 7.9 | 12 | 7.68 | 0.46 | 2.41 | 0.047 | 0.30 | 1.9 |
| 1161 | 0.5 | 0.5 | 6.1 | 6.2 | 0 | 7.33 | 0.45 | 2.30 | 0.050 | 0.75 | 1.9 |
| 1182 | 0.0 | 0.0 | 6.1 | 6.6 | 502 | 1.81 | 0.24 | 0.42 | 0.087 | 0.47 | 3.8 |
| 1182 | 0.0 | 0.0 | 6.0 | 6.2 | 516 | 1.79 | 0.16 | 0.41 | 0.096 | 0.34 | 3.8 |
| 1183 | 2.2 | 2.2 | 5.7 | 5.4 | 163 | 2.24 | 1.23 | 0.57 | 0.028 | 2.25 | 2.5 |
| 1184 | 0.5 | 0.6 | 4.5 | 4.6 | 14 | 3.40 | 1.26 | 2.35 | 0.012 | 1.65 | 1.9 |
| 1185 | 4.8 | 4.6 | 6.4 | 6.5 | 60 | 4.48 | 1.7[illegible] | 2.69 | 0.070 | 3.26 | 1.9 |
| 1186 | 5.3 | 5.7 | 5.5 | 5.7 | 258 | 3.75 | 1.35 | 1.04 | 0.012 | 3.55 | 3.5 |
| 1187 | 9.9 | 9.8 | 5.6 | 5.7 | 19 | 6.70 | 1.56 | 1.78 | 0.024 | 5.68 | 1.9 |
| 1188 | 3.0 | 3.0 | 5.0 | 5.3 | 156 | 2.65 | 0.99 | 0.79 | 0.024 | 2.06 | 5.0 |
| 1255 | . | . | . | . | 209 | 2.14 | 0.48 | 0.41 | 0.027 | 0.42 | 3.8 |
| 1255 | . | . | . | . | 217 | 2.12 | 0.42 | 0.39 | 0.028 | 0.39 | 4.4 |

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# APPENDIX B

The historical water chemistry data located for lakes surveyed in this study are presented in tabular form:

code: water code number from Appendix A

name: name of lake

year: last two digits of the year the historical data were obtained

pH: historical pH as reported

method: 1 = pH meter, 2 = colorimetric indicator

alkalinity: historical alkalinity

method: 1 = fixed endpoint titration, 2 = inflection point titration

| CODE | CODE | NAME | YEAR | PH | METHOD | ALK | METHOD |
|---|---|---|---|---|---|---|---|
| 1025 | 1025 | LITTLE LONG PD | 65 | 6.4 | . | 143 | 1 |
| 1026 | 1026 | TILDEN PD | 65 | 6.7 | . | 143 | 1 |
| 1028 | 1028 | SALMON PD | 75 | 6.8 | . | 82 | 1 |
| 1029 | 1029 | DAY MOUNTAIN PD | 76 | 7.0 | . | 245 | . |
| 1030 | 1030 | SPENCER PD | 56 | 6.8 | . | . | . |
| 1036 | 1036 | ATWOOD PD | 52 | 6.5 | 2 | . | . |
| 1037 | 1037 | BACON PD | 56 | 5.8 | 2 | 122 | 1 |
| 1038 | 1038 | DURGIN PD | 50 | 6.1 | 2 | 184 | 1 |
| 1040 | 1040 | FLETCHER POND | 56 | 6.2 | 2 | 163 | 1 |
| 1041 | 1041 | FROG PD | 49 | 6.2 | 2 | 612 | 1 |
| 1042 | 1042 | UPPER HALL PD | 50 | 5.4 | 2 | 143 | 1 |
| 1043 | 1043 | MIDDLE HALL PD | 51 | 5.9 | 2 | 82 | 1 |
| 1044 | 1044 | LOWER HALL PD | 51 | 5.7 | 2 | 61 | 1 |
| 1045 | 1045 | HEDGEHOG PD | 51 | 5.2 | 2 | 41 | 1 |
| 1046 | 1046 | KIAH PD | 51 | 5.7 | 2 | 102 | 1 |
| 1047 | 1047 | MOUNTAIN PD | 37 | 6.1 | 2 | . | . |
| 1048 | 1048 | NORTH PD | 56 | 6.4 | 2 | 143 | 1 |
| 1053 | 1053 | CROW HILL PD | 76 | 5.7 | 2 | . | . |
| 1057 | 1057 | HOWE PD | 76 | 6.7 | . | . | . |
| 1062 | 1062 | UPPER SPECTACLE PD | 65 | 6.5 | 2 | 327 | 1 |
| 1069 | 1069 | ADAMS PD | 52 | 6.1 | 2 | 61 | 1 |
| 1070 | 1070 | BEAR PD | 53 | 6.9 | 2 | 122 | 1 |
| 1071 | 1071 | CLOUGH PD | 52 | 6.5 | 2 | 163 | 1 |
| 1072 | 1072 | COLERAIN PD | 49 | 6.2 | 2 | 245 | 1 |
| 1073 | 1073 | CRANEY PD | 38 | 6.2 | 2 | 61 | 1 |
| 1074 | 1074 | CROOKED PD | 53 | 6.9 | 2 | 143 | 1 |
| 1075 | 1075 | DUDLEY PD | 49 | 6.6 | 2 | 245 | 1 |
| 1076 | 1076 | EATON PD | 49 | 5.2 | 2 | 143 | 1 |
| 1077 | 1077 | FERRIN PD | 55 | 6.2 | 2 | 102 | 1 |
| 1078 | 1078 | GILMAN PD | 53 | 6.6 | 2 | 204 | 1 |
| 1079 | 1079 | HUNKINS PD | 47 | 7.2 | 2 | 367 | 1 |
| 1080 | 1080 | KENISON PD | 49 | 6.1 | 2 | 306 | 1 |
| 1081 | 1081 | KNIGHTS PD | 51 | 6.4 | 2 | 184 | . |
| 1082 | 1082 | KNOWLES PD | 39 | 6.8 | 2 | 184 | 1 |
| 1083 | 1083 | LITTLE LONG PD | 49 | 5.9 | 2 | 204 | 1 |
| 1084 | 1084 | LONG PD | 49 | 5.2 | 2 | 204 | 1 |
| 1086 | 1086 | POVERTY PD | 38 | 6.4 | 2 | 41 | 1 |
| 1087 | 1087 | STONEHOUSE PD | 48 | 6.4 | 2 | 265 | 1 |
| 1088 | 1088 | UPPER PD | 50 | 6.6 | 2 | 102 | 1 |
| 1101 | 1101 | MOHAWK PD | 53 | 6.6 | . | 82 | 1 |
| 1103 | 1103 | CARBUNCLE PD | 57 | 6.5 | . | 0 | . |
| 1104 | 1104 | DEEP PD | 55 | 7.8 | . | 0 | . |
| 1106 | 1106 | LONG PD | 55 | 7.8 | . | 0 | . |
| 1107 | 1107 | SUCKER PD | 68 | 6.2 | . | . | . |
| 1108 | 1108 | PEEP PD | 57 | 5.9 | . | . | . |
| 1109 | 1109 | PRETTY PD | 74 | 6.2 | . | 41 | . |
| 1110 | 1110 | SALMON PD | 57 | 5.5 | . | . | . |
| 1127 | 1127 | BADDACOOK PD | 65 | 6.8 | 2 | 551 | 1 |
| 1134 | 1134 | LITTLE CLIFF PD | 65 | 6.1 | 2 | 347 | 1 |
| 1142 | 1142 | WALDEN PD | 55 | 6.5 | 2 | 82 | 1 |
| 1144 | 1144 | CARR PD | 66 | 7.0 | . | . | . |
| 1146 | 1146 | WILBUR PD | 65 | 5.5 | . | . | . |
| 1147 | 1147 | BIGELOW PD | 55 | 6.4 | . | . | . |
| 1149 | 1149 | BURR PD | 40 | 6.0 | . | 424 | . |
| 1151 | 1151 | EMMONS PD | 63 | 6.0 | . | . | . |
| 1153 | 1153 | HOWELLS PD | 53 | 6.8 | . | 82 | 1 |

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| CODE | CODE | NAME | YEAR | PH | METHOD | ALK | METHOD |
|---|---|---|---|---|---|---|---|
| 1154 | 1154 | HOLBROOK PD | 54 | 6.6 | . | . | . |
| 1156 | 1156 | NORWICH PD | 73 | 7.1 | . | . | . |
| 1159 | 1159 | UNCAS PD | 54 | 6.6 | . | . | . |
| 1162 | 1162 | IRONBOUND PD | 78 | 7.5 | 2 | 367 | . |
| 1163 | 1163 | FOLEY PD | 59 | 7.2 | . | . | . |
| 1168 | 1168 | JONES PD | 61 | 7.1 | . | 265 | 1 |
| 1170 | 1170 | TURNER PD | 63 | 6.6 | . | 184 | 1 |
| 1171 | 1171 | FERGUSON PD | 62 | 7.6 | . | . | . |
| 1173 | 1173 | UGH PD | 77 | 7.1 | . | . | . |
| 1175 | 1175 | B LAKE | 58 | 7.0 | . | . | . |
| 1176 | 1176 | MCPHERSON PD | 57 | 7.0 | . | . | . |
| 1177 | 1177 | BLUFFER PD | 76 | 7.1 | . | 286 | . |
| 1178 | 1178 | 2ND CURRIER PD | 74 | 7.1 | . | 184 | . |
| 1179 | 1179 | UPPER HUDSON PD | 52 | 6.9 | . | . | . |
| 1197 | 1197 | CAIN PD | 68 | 6.8 | . | . | . |
| 1198 | 1198 | COLBY PD | 66 | 6.0 | . | . | . |
| 1201 | 1201 | HALFMILE PD | 77 | 6.9 | . | 143 | . |
| 1212 | 1212 | ANDERSON PD | 53 | 6.6 | . | . | . |
| 1213 | 1213 | BEAVER PD | 53 | 6.4 | . | . | . |
| 1214 | 1214 | BUBBLE PD | 42 | 6.8 | . | . | . |
| 1215 | 1215 | DEBEC PD | 42 | 6.8 | . | . | . |
| 1216 | 1216 | DENNY PD | 54 | 6.9 | . | . | . |
| 1217 | 1217 | FITTS PD | 42 | 6.8 | . | . | . |
| 1218 | 1218 | HEALD PD | 55 | 6.8 | . | . | . |
| 1219 | 1219 | HORSESHOE PD | 39 | 6.8 | . | . | . |
| 1220 | 1220 | LINCOLN PD | 55 | 6.8 | . | . | . |
| 1221 | 1221 | LITTLE TUNK PD | 52 | 6.7 | . | . | . |
| 1222 | 1222 | SANDY PD | 40 | 6.8 | . | . | . |
| 1223 | 1223 | SIDE PISTOL LAKE | 54 | 6.4 | . | . | . |
| 1224 | 1224 | TRAFTON PD | 38 | 6.9 | . | . | . |
| 1225 | 1225 | TROUT PD | 53 | 7.3 | . | . | . |
| 1226 | 1226 | LEDGE PD | 64 | 6.4 | . | . | . |
| 1229 | 1229 | SPECK PD | 62 | 5.5 | . | 82 | . |
| 1230 | 1230 | TUMBLEDOWN PD | 66 | 5.6 | . | 82 | . |
| 1233 | 1233 | MOUNTAIN PD-RANGELEY | 77 | 6.5 | . | 61 | . |
| 1250 | 1250 | CONE MTN. PD | 51 | 5.2 | . | 41 | 1 |
| 1251 | 1251 | UNKNOWN PD | 53 | 6.0 | . | 122 | 1 |
| 1252 | 1252 | LOWER SAWYER PD | 48 | 6.8 | . | . | . |
| 1253 | 1253 | BLACK MTN PD | 51 | 5.5 | . | 41 | 1 |

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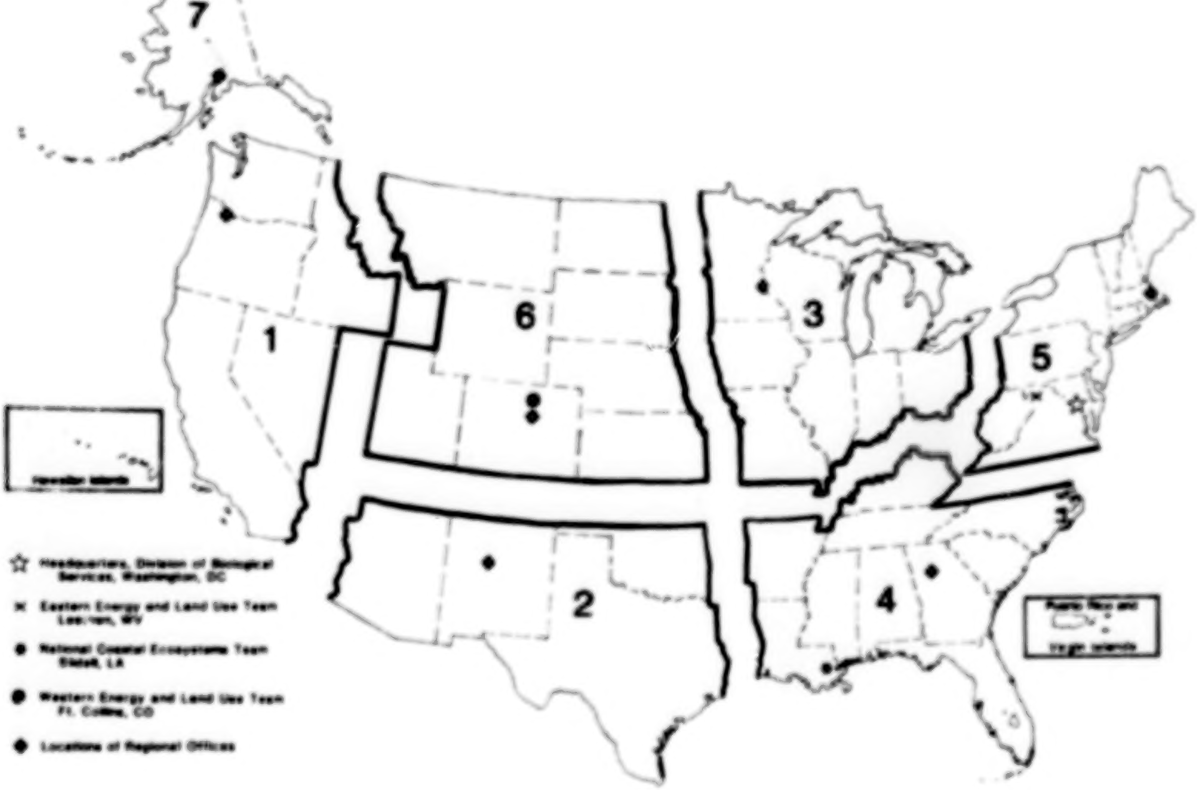
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Hawaiian Islands
Puerto Rico and Virgin Islands
☆ Headquarters, Division of Biological Services, Washington, DC
✖ Eastern Energy and Land Use Team Leetown, WV
● National Coastal Ecosystems Team Slidell, LA
● Western Energy and Land Use Team Ft. Collins, CO
◆ Locations of Regional Offices

**REGION 1**
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

**REGION 2**
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

**REGION 3**
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

**REGION 4**
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

**REGION 5**
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

**REGION 6**
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

**REGION 7**
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

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